JOURNAL

OF THE

UNITED STATES ARTILLERY

PUBLISHED BY AUTHORITY OF THE

STAFF OF THE ARTILLERY SCHOOL.

VOLUME V.

1896.

ARTILLERY SCHOOL PRESS
FORT MONROE, VIRGINIA.

Lieut. W. Robinson

V. Complete

JANUARY—FEBRUARY.

Vol. V. No. 1. Whole No. 18.

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ENTERED AT THE POSTOFFICE AT FORTRESS MONROE, VA., AS SECOND-CLASS MATTER

UNITED STATES ARTILLERY SCHOOL,

FORT MONROE, VIRGINIA.

The *Journal of the U. S. Artillery* is, by authority of the Staff, published at the Artillery School as a bi-monthly.

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Subscription $2.50
For countries in the postal union $3.00
Single numbers $0.50

Subscriptions in all cases date from January 1st. Address all communications and remittances to the editor, at Fort Monroe, Virginia.

AGENTS.

NEW YORK—*Dyrsen & Pfeiffer*, successors to
F. W. Christern, 254 5th Avenue.

LONDON—*B. F. Stevens*, 4 Trafalgar Square.

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VOL. V. No. 1. JANUARY 1896. WHOLE No. 18.

SEA-COAST DEFENSES AND THE ORGANIZATION OF OUR SEA-COAST ARTILLERY FORCES.

BY COLONEL THE HONORABLE WM. CARY SANGER,
ASSISTANT CHIEF OF ARTILLERY, S. N. Y.

INTRODUCTION.

DEFECTS IN OUR PRESENT MILITARY ORGANIZATION.

In a recent article I called attention to the statement made by one of the most eminent authorities on the military and political conditions of Europe, that "the present position of the European world is one in which sheer force holds a larger place than it has held in modern times since the fall of Napoleon." The vast armies and powerful navies of Europe which are maintained at such enormous cost, are the inevitable consequences of this "Reign of Force," and prove the truth of Sir Charles Dilke's words; but his statement is only half the truth, for never in the history of the world has sheer force been so dependent upon brain work to prepare it to strike its most effective blows; organization, discipline and the effective working of the administrative departments are as essential to success in modern warfare as the numerical strength of the fighting force, or the military ability of its leaders. It was because the Germans, after years of work and study, had perfected the organization and training of their forces, and had mastered the problems of modern warfare, that they were able to pour officers and men across the frontier, in such numbers and in such condition that the "sheer force" of France, without proper organization or adequate training, spent itself in vain.

The late Lieutenant General Sir Edward Bruce Hamley, in "The Operations of War," has made the statement that "the fate of the enormous levies raised from the French population in 1870-71, after the destruction of the regular armies, has convinced all who needed convincing, how worse than futile is the attempt to meet" discipline and organization with numbers. Lieutenant General Schofield has truly said, that "proper organization is more important than numbers." It is no exaggeration to say that what defeated the French was the work done in organizing and training the German forces during the twenty years which preceded the war, and that the French were practically beaten before the first shot was fired.

Europe has learned the lesson which the Franco-Prussian War taught; all the great nations of the world, except America, have studied the military problems which confront them, and have endeavored to secure the best possible organization for their forces; Japan's unbroken series of victories over her foe, geographically and numerically so great, is but the latest illustration of what all future wars will prove; but regardless of proof, we bury our heads, ostrich-like, in the sands of indifference and ignorance; there has been more advance in military science during the past twenty-five years than in any preceding century, yet we have done but little to improve the organization of our military forces. The Honorable Daniel S. Lamont, Secretary of War, in his report submitted to the President, November 1895, says: "The organization of the line of the army has undergone no material change since the close of the civil war. During this period of thirty-years every large foreign army has been completely reorganized." With great wealth and millions of able-bodied men, we have neglected those simple precautions which common sense and military knowledge point out as necessary, and as a result of this "policy of indifference," the lives and property of our people and our national honor are at the mercy of a dozen possible enemies.

Arguments may be advanced to prove to the satisfaction of many of our citizens that we should not keep a large standing army; but can a single American be found who will argue that what forces we have should not be well organized, or that we should retain a defective or imperfect organization?

To say that we should have some carefully thought out plan for enrolling the forces which we may at any time be compelled to call into active service, would seem to be but stating a truism, but the importance of this simple and fundamental principle has

been ignored by us. It is but right that we should recognize the defects of our military system because a realizing sense of the evils which mar our present organization should help us to avoid their repetition in the future. It is not an exaggeration to say that at the present time the armed forces of the United States as a whole are without organization. We have an army 25,000 strong, which is numerically impotent to wage unaided an aggressive or defensive war of any magnitude. We have forty-seven entirely separate and distinct state forces, with a total strength of 115,000. These forces are in no sense a reserve to the regular army; they can hardly be said to constitute an auxiliary force in the proper sense of the word. They are independent forces, organized without any regard to their relations to each other, or to our military forces as a whole; without regard to national needs, and without any recognized plan for their co-operation with each other or with the army. It cannot be expected that forces which are organized under so many different authorities would have anything like a proper proportion of the various arms, nor is it possible that they can have the cohesion necessary for a successful fighting force.

Some of the state forces are not only competent to supplement the police and preserve order in the state, as has been shown on many occasions within recent years, but are also well disciplined, well drilled, and capable, after a short experience in the field, of rendering valuable and important service. But so far as the defense of the coast is concerned there is no state in which the militia is adequate in numbers, or competent in point of efficiency, to protect its state against the dangers to which it is exposed; and in many of the states the militia is not even organized or trained for this important work.

The antiquated law, which is still in force on the statute book of the United States, requires every citizen between the ages of 18 and 45 to provide himself, among other things, with a good musket or firelock and two spare flints, and directs that each commissioned officer shall be armed with "a sword or hanger, and a spontoon." Under this law there are over 8,000,000 men liable to military service, but there is no plan for creating the batteries or regiments which they would form.

NEED OF RECOGNIZED AUTHORITY TO DECIDE MILITARY QUESTIONS.

I cannot refrain from saying at the outset that in my judgment one of our greatest military needs to-day is a body of

officers with authority, duties and responsibilities similar to those of the German General Staff. Such a body of officers should be the recognized authority to study and report upon those theoretical and practical problems, the right solution of which is at the present day so essential to the success of a fighting force. It is well known that when the German General Staff reaches a conclusion on any military subject the entire nation accepts that conclusion as final.

England and America offer a striking contrast to this. Both of these countries are entirely without any such recognized military authority. With us the artillery point out their needs, the infantry theirs, enthusiastic militiamen call attention to the defects in their force; but there is no consensus of opinion on these subjects, no treatment of these questions from the broad and comprehensive standpoint of the nation's need: and the ablest opinions on any subject have for the public no more weight or importance than is accorded them by the few individuals who take the trouble to study them. Furthermore the officers in the same arm of the service often disagree regarding the needs of the service, and with us, as in England, officers high in authority often advocate the most opposite action on important military questions: it has happened that the Lieutenant General of the army and the Adjutant General have differed diametrically in their recommendations to the Secretary of War on the same subject.

NEED OF CONSENSUS OF OPINION ON MILITARY QUESTIONS.

As we have no official board like the German General Staff whose conclusions on purely military matters are accepted by the entire people as final, we must attain the same end by a consensus of opinion. If the military authorities of the country, and those men who are prominent in shaping public thought in civil life, should agree upon some plan of organization for any arm of our force, it would be comparatively easy to secure its adoption. It is of the utmost importance that this agreement should be reached in regard to the organization of the sea-coast artillery, if we are to escape the evils which result from leaving questions of organization to be settled in different ways in different localities—an evil which our military history records with distressing frequency.

It would be quite as easy to devise a plan for the wise re-organization of all our armed forces as to determine how we can best organize one branch of the service. But it has seemed best that

this discussion should be confined to questions which concern the sea-coast artillery, so we must not here consider those who with our field guns, or in the saddle, or with their rifles, will be unnecessarily sacrificed if the organization and training of our military forces is not better in our next war than it was in 1861.

I have divided this article into two parts: in the first I have repeated much that is well known to many readers of the *Journal* regarding the need of adequate coast defenses; and in the second I have considered the questions which relate to the organization of the force which is to do duty at the sea-coast guns.

The presentation of facts bearing upon both of these questions has lengthened the paper, but it has been so subdivided that the reader can easily limit his attention to those subjects in which he is expressly interested.

In these pages I have re-produced almost entirely an official report which I submitted in 1894 to the Adjutant General of the State of New York, and I have made extended extracts from previous articles which I have written on this subject, some of which have appeared in the *Journal of the Military Service Institution.*

PART I.

The Need of Adequate Coast Defenses.

A BRIEF RETROSPECT.

There has never been any considerable proportion of the American people who have advocated ignoring entirely the material means for defending our shores, but ignorance, misunderstanding and indifference regarding the subject of coast defenses have been so common that the country during the last twenty-five years has pursued a halting, vacillating policy, entirely without justification from any standpoint.

It should be clearly understood that there are but two courses open to the people of our country: either they should refrain entirely from preparing the means of defense, or they should provide for a defense so strong as to be effective against any foe that might attack us. There would be at least consistency in leaving our coast entirely undefended, trusting exclusively to diplomatic negotiation and to arbitration for the settlement of international misunderstandings; but if we are not prepared to adopt this plan the only other consistent course is to make adequate preparation to protect ourselves if attacked or forced into a war with some foreign power. Any middle course is not merely foolish, it is wrong, and cannot be defended upon any

ground. To send officers and men into forts which are known to be unable to withstand the attacks of modern naval guns, to order them to serve guns which are known to be useless against modern armor, is but to order them to certain destruction, and while officers and men stand ready to obey such orders to-day, it would be little to the credit of the nation to demand such an unnecessary and useless sacrifice of life. Inadequate, obsolete and inefficient coast defenses are worse than none at all, and no argument can be made in their favor. Our action in building a new navy, and in beginning the work of carrying out the recommendations of the Fortifications Board, has committed the nation to the alternative of making its defenses adequate; but money has been so grudgingly appropriated by Congress that the work of completing our harbor fortifications is progressing with lamentable slowness. A thorough understanding of the question by the people is all that is needed to secure the requisite appropriations by Congress, and to insure the popular approval of some wisely devised plan for organizing the force necessary to make the forts and guns effective. I have therefore thought it proper, before taking up the problems of organization, to repeat some of the well known arguments which prove the wisdom and economy of adequate defenses; for although questions concerning the organization of our sea-coast forces are, in one sense, distinct from those which concern the building of forts and guns, their discussion in the same article is entirely fitting; and especially is this the case when it is hoped that the article will be read by some of our citizens who have not given the subject of our coast defenses careful study or attention.

Time and again officers of great ability and sound practical judgment have described our defenseless condition, and have exhaustively and convincingly shown the wisdom and necessity of having adequate coast defenses; but time and again the people have ignored the facts and arguments. The wisest prophets have, Cassandra-like, recounted the possibilities of the future only to find that incredulous or indifferent listeners had turned deaf ears. I cannot expect to present any new facts, but I am not without hope that if plain truths are told often enough their importance may eventually be realized by the people whose interests are most vitally concerned.

At the outbreak of the civil war, the fortifications and armament of the sea-coast of the United States were among the best in the world, and at the close of the war the United States had become, as Gen. Schofield had said, "the most formidable in

every respect of the great nations of the world." But the succeeding years saw a complete change. Gen. Schofield, while commanding the Division of the Atlantic, in a report of great interest, stated that although the country "had increased very greatly in population and immensely in wealth, it had become by far the feeblest in a military sense, of all the nations called great."

While this change was taking place no reason was ever given why we should thus reverse our hitherto unbroken policy of keeping our coast defenses in good condition. As a matter of fact the neglect of our defenses was not the result of deliberate judgment; it was entirely the result of indifference. Amid the multiplicity of commercial and industrial problems which engrossed the attention of the entire nation at the close of the civil war, the question of coast defenses was simply ignored.

THE APPOINTMENT OF "THE ENDICOTT OR FORTIFICATIONS BOARD."

At last the repeated warnings and protests of officers of the army and navy, and civilians whose opinions were entitled to so much weight that they could not be entirely ignored, induced Congress to consider the situation, and in 1885 they directed the President to appoint a board to report what fortifications or other defenses were most urgently needed, and in 1886 this board, which has been called the "Endicott or Fortifications Board," submitted its report, which contained the most authoritative and comprehensive discussion of our sea-coast defenses that has ever been submitted to the public. Among other things the Board says: "It is of no advantage to conceal the fact that the ports along our coast—a length of about 4,000 miles not including Alaska,—invite naval attack, nor that our richest ports, from their greater depth of water and capacity to admit the largest and most formidable ships, are, of all, the most defenseless."

"The property at stake exposed to easy capture and destruction would amount to billions of dollars, and the contributions which could be levied by a hostile fleet upon our sea-ports should be reckoned at hundreds of millions."

The "Fortifications Board," recognizing the peril of the situation, made most careful estimates of the number and character of guns and mortars, as well as of the location and character of the fortifications needed. The accuracy of their conclusions and the wisdom of their recommendations have never been questioned. The estimate for the necessary land defenses and arma-

ment of New York state, including floating batteries, sub-marine mines and torpedo boats, was $23,000,000; the grand total for the country was $125,000,000, and the annual appropriation recommended to be made until the work should be accomplished was $9,000,000. The Board says: "After mature consideration, and with all the information before it, the Board is of opinion and recommends that the above amounts should be appropriated by Congress without delay for the purposes mentioned;" and it further states that "nothing less will suffice even for a beginning."

In the year following the submission of this report, Congress manifested its appreciation of the existing conditions by making no appropriation whatever for land defenses or armament; in 1888 $100,000 was appropriated for the "preservation and repair" of existing fortifications, and in the seven years which followed 1888 Congress appropriated for "plans," "sites," and "guns" and "mortars," $4,700,000, or a trifle over one-half the sum recommended as the smallest which would suffice for an annual appropriation in order to make "even a beginning."

In the report from which I have quoted, the Secretary of War addressing himself to the President says: "In your annual message transmitted to Congress in December, 1886, attention was directed to the urgent necessity for seacoast defense in these words: 'The defenseless condition of our seacoast and lake frontier is perfectly palpable; the examinations made must convince us all that certain of our cities should be fortified and that work on the most important of these fortifications should be commenced at once. The absolute necessity, judged by all standards of prudence and foresight, of our preparation for an effectual resistance against the armored ships and steel guns and mortars of modern construction which may threaten the cities on our coast is so apparent, that I hope effective steps will be taken in that direction immediately.'"

The Secretary then continues: "Since that time the condition of these defenses has been under grave consideration by the people and by this Department. Its inadequacy and impotency have been so evident that the intelligence of the country long since ceased to discuss the humiliating phase of the subject, but has addressed itself to the more practical undertaking of urging more rapid progress in the execution of the plan of defense devised by the Endicott Board in 1886, with subsequent slight modifications.

"That plan contemplated a system of fortifications at 27 ports

(to which Puget Sound was subsequently added), requiring 677 guns and 824 mortars of modern construction, at a cost of $97,782,800, excluding $28,595,000 for floating batteries. By an immediate appropriation at that time of $21,500,000 and an annual appropriation of $9,000,000 thereafter, as then recommended, the system of land defenses could have been completed in 1895.

"The original plan contemplated an expenditure of $97,782,800 by the end of the present year. The actual expenditures and appropriations for armament and emplacements have, however, been but $10,631,000. The first appropriation for guns was made only seven years ago, and the first appropriation for emplacements was made only five years ago. The average annual appropriations for these two objects has been less than $1,500,000. The work has therefore been conducted at about one-seventh the rate proposed..

"If future appropriations for the manufacture of guns, mortars, and carriages be no larger than the average authorized for the purpose since 1888, it will require twenty-two years more to supply the armament of the eighteen important ports for which complete projects are approved.

"If the appropriations for the engineer work are to continue at the rate of the annual appropriations since 1890, it will require seventy years to complete the emplacements and platforms for this armament for the ports referred to.

* * * * *

"It rests with Congress to determine by its appropriations the period which shall elapse before our coasts shall be put in a satisfactory condition of defense. The amount required for the 18 ports is about $82,000,000, and the entire work can be completed within ten years. The rate of progress will be slower in proportion as appropriations are kept below the amount which can be advantageously expended."

LACK OF PREPARATION FOR WAR ENTAILS WASTE OF LIFE AND TREASURE.

There is a certain sad consistency in this action, for it seems to be our national policy not to be prepared for war when it comes, and then cheerfully to sacrifice life and money with the reckless prodigality of the spendthrift.

While the ominous mutterings of the approaching storm of civil war forced our wisest statesmen to recognize the coming of

an "irrepressible conflict," the country was unwilling to make any adequate preparation for it. In 1861 we had an army of 14,-663 officers and men; we had an imperfectly organized, defectively equipped and badly-disciplined militia, and we had no recognized plan for enrolling or organizing our armed forces; our lack of adequate preparation cost the country in lives and money vastly more than would have been the case had ordinary common sense directed our action in the five or ten years preceding 1861. The nation paid out over $6,000,000,000 before the war ended, and no one can estimate the unnecessary cost and suffering which our lack of proper preparation and organization entailed.

General Hunt, in the concluding paragraph of his last official report as commander of artillery of the Army of the Potomac, makes this statement: "I do not hesitate to say that the field artillery of this army, although not inferior to that of any other in our service, has been from one-third to one-half less efficient than it ought to have been, whilst it has cost from one-third to one-half more money than was necessary. This has been principally due to want of proper organization." And what General Hunt says of our field artillery was equally true of other arms of the service.

The American people have always been willing to expend the most extravagant sums of money after war has begun, but they begrudge the relatively small amounts which, wisely spent in advance, would either prevent war or greatly reduce its cost.

In 1887 Congress refused to appropriate a penny for the defenses which a board of unquestioned ability declared should receive at least $9,000,000 annually, but it paid with avidity over $75,000,000 in pensions; in 1892 the appropriation was over $134,000,000, and since 1861 over $1,000,000,000 has been paid to pensioners of the War of the Rebellion. While Congress is eager to pay out these enormous sums of money, it grudgingly appropriates a mere pittance for insurance against the dangers of future wars. Adequate preparation in 1861 would have shortened the duration of the war, would have lessened the actual cost of carrying it to a close, and would have lessened the number of men entitled to pensions. Preparation for war is economy, and the cost of our late war, entirely apart from the magnitude of the pension appropriation, illustrates the unquestioned truth, which cannot be too strongly emphasized, that the most wasteful and extravagant folly which a great nation can commit is to enter upon a war without adequate preparation.

It should not be forgotten that we always have been and always

will be ready to go to war whenever circumstances make it imperative that we should defend the rights or the honor of the nation. In 1812 we declared war against the greatest maritime power in the world, although we were practically without a navy, and were in every way unprepared for the contest. While it is true that we have never been beaten, yet our wars have, in every instance, cost us vastly more in life and treasure than was necessary, and the expense of future wars will make those that are past seem insignificant by comparison.

Much as we desire peace, war is an ever present possibility. No one can deny that international complications, which might lead to war, are always possible. As in the case of our recent diplomatic correspondence with Chili, we are liable to find ourselves so situated that the question of war or peace is not for us to decide, and depends entirely upon the action of some foreign power; and there are millions of men who would demand an immediate declaration of war if diplomatic correspondence failed to protect the rights or honor of the nation.

ECONOMIC ARGUMENTS IN FAVOR OF ADEQUATE COAST DEFENSES.

It is a principle established by all the wars of recent times, and emphasized by our own experience, that adequate preparation reduces the cost of war, and yet the economic importance of being ready for war has been ignored by us. It seems strange that so practical a people as we are should be so slow to realize the pecuniary advantages of being thoroughly defended against foreign enemies. The strongest arguments for adequate defenses are not sentimental ones; they are business ones; they are economic ones. We should be capable of defending ourselves because we thus make ourselves less liable to attack, and because we thus lessen the burden and losses which war inevitably entails.

1. Argument of General Abbot of the U. S. Engineers.

General Abbot states the business side of the question very clearly when he says: "All that the engineers demand is a fair hearing and a discussion of the question in business-like way.

"From one point of view expenditures for sea-coast defenses should be regarded simply as a necessary business outlay entailed by the possession of wealth, and should be governed by the usual rules of insurance so far as they can be applied. A citizen of New York pays a certain percentage of his property toward the support of a fire department, because he is convinced that the outlay is demanded by true economy as a protection against

loss by fire: he pays another tax to maintain the police department to afford security against individual violence and robbery: he contributes his assessments in support of the National Guard, because he knows that mobs are a danger to life and property which timely precautions alone can control. Finally, not satisfied with these precautions, his business instincts teach him to pay large sums for insurance, to reimburse him for losses which may possibly overtake him in spite of all his forethought. It seems amazing to one who has reflected on the subject that this same man appears to forget that war, liable at any time to occur, may result either in the burning of his property under circumstances which will cripple the fire department, disperse the police and National Guard, and bankrupt the insurance companies, or else will subject him to enormous impositions to purchase exemption from other destruction. Surely all history proves that this danger is real.

"It must not be overlooked that, in some important particulars, funds invested in sea-coast fortresses are far more advantageous than ordinary insurance. Thus, instead of merely distributing the loss among many individuals they prevent it altogether. Moreover, large continuous outlays are not required. The works are imperishable, and the annual premiums are, therefore, small. A port once provided with adequate defenses remains in security until new progress in the art of war demands modifications. In a word, their utility is as permanent as anything human."

2. *Argument of Lieutenant Griffin of the U. S. Engineers.*

In 1885 Lieutenant Griffin of the Engineers prepared a valuable paper on our sea-coast defenses. In it he made the following statements which are as true to-day as when they were written—with the one exception that the value of the destructible property has greatly increased.

"A hostile fleet lying in the upper bay of New York would have within reach of their guns about $2,000,000,000 worth of destructible property in New York City alone, and including Brooklyn and Jersey City, over two and a half billions. Their guns would be of the largest caliber, many of them capable of throwing sixteen and seventeen-and-three-quarter inch shells charged with seventy-five pounds of explosive gelatine.

"We have but a slight idea of the completeness of demolition which would result from the explosion of seventy-five pounds of of nitro-gelatine in the interior of such a building as the New York Stock Exchange. There are below Chambers Street in

New York City, eight buildings the assessed value of which for 1885 was over $12,000,000. Every one of these might be wrecked by just eight happily directed shots. Yet the value of these buildings alone would more than suffice for the complete defense of the southern entrance to New York Harbor, including works, armaments and torpedoes of the most modern type.

"New York City pays over $1,500,000 annually for its fire department, and over $6,000,000 are paid annually for fire insurance.

"War may do New York City more injury in one day than fire would in a century. Such being the case, it insurance against fire is worth $18,000,000 triennially, is not insurance against war worth a single payment of $17,500,000?"

We must remember that New York and the eastern seaboard are not more deeply interested in this question than the cities and states on our western shores. General Miles, when commanding the Division of the Pacific, said in his annual report of 1889:

"The most important subject to the Pacific coast states, and one that should receive the earnest and immediate attention of government, is the defense of the Pacific coast. It is of such vital national importance that I regard it neither wise nor patriotic to longer delay its improvement. We have not reached that perfection of human society in which it is safe to trust ourselves in a defenseless condition. * * * As the entire system of warfare has changed within a generation, we cannot rely upon the achievements of our fathers. or the boasting of our own people to defend our political rights, property or lives. The condition of this coast is one to tempt the avarice and cupidity of any fourth rate naval power on the globe, and that it would be occupied by any first class naval power is a fact apparent to any thoughtful well informed citizen. Such occupation would be not only of a temporary character, but would be for a term of years in which all business interests would be paralyzed, and all values of property seriously depreciated, and the wealth accumulated during generations by economy and industry be destroyed in a few weeks' time. It is but a few years since the ports of a large section of our country were so thoroughly blockaded as to cripple the military power of nine millions of people. No competent judge will deny the fact that it is equally possible to blockade every important port of our country in the same way within ninety days, and that it would take many years to make a successful resistance against such a power. In fact it has been

estimated by competent authority that our country might be placed under an indemnity to the extent of five billions in money.

"On this coast line there are more than five hundred millions of dollars involved in destructible property within the reach of naval vessels. The indemnity need not necessarily be in the shape of money, but the staple products of the country would be just as valuable to any foreign nation, and should one-half of it be used to reduce their national debt, and the other to double or quadruple their naval power, the time of our successful resistance, when once forced out of deep water by such a power, would be at least indefinite, as there are several strategic positions on the Pacific coast which, if captured and reversed, could be used against us and rendered as impregnable as Gibraltar. * * Military and naval officers have reported and recommended for years the improvements in the condition of the defenses of this nation; legislatures, boards of trade, chambers of commerce and commercial conventions have petitioned and prayed the general government to take action in this matter, and yet the wretched defenseless condition of the coast has continued to the present moment. * * *

"It is embarrassing for a military officer to acknowledge this condition of affairs and to record these facts. Yet he would do less than his duty to his country, did he not endeavor to bring the truth before the government, in order that it should be fully apprised of the true condition of affairs."

In his report of November, 1895, as General Commanding the Army, General Miles calls attention to the fact that with the exception of the slight progress made in the defenses of the harbor of San Francisco, the conditions above described are unchanged.

THE NAVY AND SEA-COAST DEFENSE.

It is perhaps proper that I should say in this connection a few words about our navy. There are some who think that a strong fleet would do away with all necessity for land defenses; there could be no greater fallacy than this; the officers of the navy would be the first to repudiate the theory. No defense can be considered adequate which does not consist of sufficiently strong fortifications and armament on shore. Ships can never take the place of land defenses, and any attempt to have them do this would be a shameful perversion of the navy's proper sphere, leading only to failure and disappointment. If our navy were

complete, as we hope it will be in the not very distant future, it would be wicked and wasteful to relegate it to the place which should be occupied by land forts and floating batteries. A navy without land defenses would be as wasteful an expenditure of money and talent as an elaborate fire department without an adequate water supply. Even those naval officers who would extend the authority of the navy over all harbor defenses, would unanimously urge the imperative necessity of land fortifications, and would deny the possibility of properly defending a harbor with ships alone.

Major General Miles, in his annual report of 1895, from which I have already quoted, says: "There are two delusions which seem to be misleading in this country. One is that torpedoes can be depended upon to protect the accumulated wealth of three hundred years, that is located along our seaboard and navigable rivers; and the second is that our coast of four thousand miles in extent can be defended by a navy. Torpedo plants would be useless without batteries to protect them, and in the entrances to several of the harbors the water is of such depth as to make it impossible to utilize torpedoes. At high water, swift light draught gun boats and torpedo boats can pass over the torpedo mines without danger. It is useless to suppose that a small navy like ours could protect such an extensive coast, embracing many of the principal cities of the country and a large proportion of the wealth. The recent maneuvers in England demonstrated that even with the powerful navy of the British Empire, it would be impossible for their navy to defend the coast of that island against a foreign fleet. In case of war our navy would have ample field for service in foreign ports and against foreign commerce."

It seems proper to call attention to the fact that the suggestions contained in this article would not be in any way affected by the final determination of that interesting question, whether the control of our coast defenses should be left to the army or transferred to the navy.

I have discussed our sea-coast defenses at some length, because it is a question which many people do not understand, and in regard to which it is of the utmost importance that there should be an intelligent opinion.

We have made gratifying progress in the building of our new navy. We have a carefully-considered plan for our coast defenses, and yet, owing to the indifference of the public as

manifested in Congress, eight years have passed since the plan was submitted.

Unless we are willing to do away with all preparation for war, are willing to abandon the policy which the nation adopted when it began to build a new navy, and to manufacture heavy guns for our harbor forts, it is the imperative duty of the nation to spend enough money to protect our sea-coast. Our duty in this regard rests upon patriotic and economic reasons, which, if thoroughly understood by the people, would receive their hearty assent and approval.

PART II.

The Organization of our Sea-Coast Artillery Forces.

We have now considered some of the arguments which prove the need as well as the economy of adequate coast defense and we have seen that the country has by its action committed itself to the policy of protecting our coasts with forts and guns; but there has been no plan or system adopted for enrolling or training the men to serve these guns: it therefore becomes a question of the most vital importance how we shall organize the forces without which forts and guns are worse than useless.

DEFINITION OF ORGANIZATION.

The word "organization" is used in this article as meaning the plan or system in accordance with which the component units of a military force are constituted, and by which the functions and relations of the different units to each other and to the force as a whole are determined.

It is hardly necessary to say that the best organization is that which enables a force to do its work most successfully, with the lowest cost to the tax-payer, and the least burden to the citizen.

In order that any armed force may be well organized it is necessary that the purpose for which the force exists and the work which it will have to do, must be clearly understood, and the system adopted must be in harmony with the political and social conditions of the people.

The superiority of the German military organization, so strikingly proved in the Franco-Prussian war, was due to the fact that the Germans saw clearly what their army would have to do, and they then developed the system which was best suited to give them an effective force, and which was in harmony with their national character and institutions.

So we, in organizing our sea-coast artillery, should recognize

clearly what that force must be prepared to do, and we should then formulate the plan or system which, under our political and social conditions will in the best way give us what we need.

STATEMENT OF THE PROBLEM.

At the outset we must recognize certain fundamental facts which practically determine the character of the problem to be solved.

The work which an artillery force must do in the future is totally different from that which had to be done in the past. The character of modern armament is such that it requires scientific knowledge and technical training far beyond anything required of any arm of the service in past times. General Miles in speaking of modern artillery work has recently said: "It is a branch of science that cannot possibly be learned in a short time, but requires years of careful study and practice to enable men to become proficient." Modern sea-coast guns and mortars would be utterly worthless without an adequate number of officers and men to serve them who had had the proper training necessary to enable them to make the guns effective.

To be a thoroughly trained artilleryman in the present day necessitates a wider range of technical and scientific knowledge than is required in any other arm of the service.

The ideal artillery officer should understand military engineering, gun construction and the metallurgy of gun metal, interior and exterior ballistics, steam and mechanism, electricity and mines, chemistry and explosives, military science, telegraphy, photography and cordage, in addition to being master of all that is contained in the 500 pages of the "Manual of Heavy Artillery Practice."

It is not supposed, however, that more than a relatively small proportion of our entire fighting force will be proficient in all these subjects. But the minimum knowledge which should be possessed by the officers and men who go into the harbor forts should cover the following ground:

They should understand the "Formation of the Battery" and the simple marching maneuvers necessary to get the men to the pieces.

They should know the "Manual" of at least one piece of heavy ordnance, and their instruction should cover the service of smooth bores, rifled pieces and mortars.

All should understand the "Definitions" in the "Manual of Heavy Artillery" and the use of the artillery implements, and

some in each command should have a general knowledge of the different kinds of gunpowder, and of projectiles, fuses and primers.

All officers should have a fairly accurate knowledge of the motion of projectiles and deviating causes, such as direction and force of wind, density of atmosphere, state of barometer and temperature, and should know the principles of aiming guns and mortars, and they should be familiar with the different kinds of gun carriages and platforms.

In addition to this, all officers and non-commissioned officers should understand the use and reading of azimuth circles, and should be able to set or read any given number of degrees and minutes with great rapidity; they should understand the use of verniers and direction of wind, density of atmosphere, state of barometer and temperature.

Some in each command should understand the care, preservation and proper use of ammunition.

We have as a people adopted a plan of coast defense which will require as a minimum 85,000 officers and men in time of need, a certain proportion of whom must be thoroughly educated and trained in order to make our coast-defenses effective.

We are irrevocably opposed to the creating or maintaining a large standing army.

We must rely upon voluntary enlistment in the creation of any military force.

With these facts before us the question which we have to answer is, what is the best plan or system for securing the necessary officers and men adequately trained to make our defenses effective?

Believing that the principles which should govern the organization of the force ought to be settled before we are drawn into a discussion of matters of detail, I desire in what follows to limit myself to the statement and discussion of broad and fundamental principles, leaving many interesting and important questions for consideration at another time. I cannot refrain, however, from referring to the able articles which have discussed questions connected with the organization of a sea-coast artillery force; with a full appreciation of the value of the suggestions which have been made by many officers, I desire to call especial attention to the article of Lieutenant Allen, Fifth Artillery, U. S. A., in No. 15, Vol. IV., of the *Journal*, which discusses with force and clearness not only fundamental principles, but

also many questions of detail which must sooner or later be finally settled.

In what follows I have outlined a plan for organizing an adequate force, and in order to facilitate criticism upon it I have formulated certain propositions embodying the fundamental principles which, in my judgment, should govern the organization of our sea coast artillery forces; it is to be hoped that their presentation in this article will call forth such expressions of opinion, favorable or otherwise, as will practically determine whether or not they should be adopted.

STATEMENT OF PRINCIPLES WHICH SHOULD GOVERN THE ORGANIZATION OF OUR SEA-COAST ARTILLERY FORCES.

1. The sea-coast artillery arm of the army must be increased.

2. Auxiliary sea-coast artillery formations must be organized, because the regular army will never have enough artillerymen to serve our sea-coast guns in time of war. These auxiliary forces should be created in two ways:

First, sea-coast artillery formations should be organized in the national guard or militia, as now constituted in the several states, whenever the states will undertake to do this.

Second, a new sea-coast artillery force should be created.

3. In order to secure uniformity of organization and harmonious action, there should be one plan or system for the organization of our sea-coast artillery forces, and all the different units of the several forces should be given their proper places in the system.

4. All our sea-coast artillery forces should be given a reserve of their own, by adopting the system of short service with the colors, followed by a period in the reserve.

5. The territorial or localization system should be adopted for our sea-coast artillery forces; the country should be divided into artillery districts, and the force in each should be recruited chiefly from men located in the district.

6. All the sea-coast artillery forces should be organized and trained with a view to suddenly calling into the forts enough men, sufficiently trained, to make the guns most effective against a foreign foe.

NEED OF INCREASING THE ARMY.

1. The sea-coast artillery arm of the army must be increased.

The mere statement of the number of officers and men necessary to make effective our new sea-coast armament, renders argument unnecessary to prove that the sea-coast artillery arm of the army must be increased. The lowest estimate of the forces which will be needed is 85,000.

We have to-day in the army in round numbers 3,200 men trained as heavy or sea-coast artillery, about half enough to serve the guns now in the New York harbor forts for one day's action, less than one-quarter of the total number that will be required in the New York harbor forts when the new armament is complete,

and about four per cent. of the total number which will be needed for the entire coast.

Opinions might differ regarding the proportion of our 85,000 artillerymen which should receive the scientific and practical training which is now given to the officers and men in the army in this arm of the service, but no one will deny that the present numerical strength is inadequate. In his last report Major General Miles says: "It is perfectly well known that there is absolute necessity for the increase of the artillery arm of the service, for the purpose of manning, protecting and caring for these valuable weapons of war. The army should grow as the nation grows. There is no reason why it should become crystalized. It is one of the pillars of the nation. It is the main dependence of the civil government, that guarantees protection to life and property, and is the main reliance of the nation in case of war with any foreign power.

"In my judgment, it would be wise and patriotic to fix a reasonable standard by which the strength and numbers of the army would be conditioned upon the ever-increasing wealth, population, and requirements of the nation."

The necessity for adopting a system which will provide a way for increasing our artillery strength with the least possible cost to the tax-payer is made plain when we consider how insufficient our present force is. If we were involved in war, our first and greatest, one might say our only danger, would be from attacks upon our sea-coast cities, such as New York, Norfolk, San Francisco, Boston, etc. Our artillery could not garrison the forts which we possess. or serve the few guns now in them. Take for example the forts in New York harbor. There are at present mortars, serviceable smooth-bores, and converted and other rifles mounted, or in position to be mounted, in the New York harbor forts which would require for a single day's action, with three reliefs, over 7000 men. The Fortification Board stated that the proper defense of New York harbor calls for over 200 additional guns and mortars. These guns would require at least 6000 additional men. If the recommendations of the Board were fully carried into effect we would require at the lowest estimate 13,000 artillerymen for New York harbor, and 85,000 for all our forts. But considering for the moment the conditions as they now exist, we find that New York alone, with its present insufficient armament, needs over 7000 artillerymen for one day's action. We have at present 3000 artillerymen in the army, and if they were all sent to New York harbor, there would be over 3000 men

too few to serve the present insufficient number of guns in one day's action. One might suppose that the New York militia would be the force to supply the needed men, but of the 13,000 men who now compose that force there is not, if we except the naval militia, one company trained to serve heavy sea-coast guns, or guns of position; nor does any one know how the necessary batteries would be organized or trained. The efficiency of the naval militia and its ability to render valuable service afloat or on shore, are recognized by all, but it is organized as a naval force, and it is proper to assume that it will be called upon in time of war to do other work than serve the guns in our harbor forts. The fact that the state of New York has no heavy artillery force does not result from any lack of appreciation by the state authorities of the need of such a force; but the proper organization of an adequate artillery force raises so many and such important questions that it has been thought best to give the subject such careful thought and thorough study that when action is once taken it will accomplish the desired end in the best possible way. The proportion of the total strength which the army should supply can be and should be determined by the proper authority; but without discussing this question now we may state as a self-evident proposition which does not need additional proof or argument, that the sea-coast artillery arm of the army must be increased. When our military authorities have agreed what this increase should be, all citizens should unite in demanding that Congress make the necessary appropriations.

NEED OF AUXILIARY FORCE.

2. *Auxiliary sea-coast artillery formations must be organized because the regular army will never have enough artillerymen to serve our sea-coast guns in time of war.*

It is an indisputable fact which no one can question, that the army can never supply all the officers and men needed to man our sea-coast fortifications. It will be necessary to supplement the army, and we should know in time of peace under what plan these additional men are to be enrolled and how they are to be trained.

If we should make the fatal error of relying exclusively on our army, and the sea-coast artillery arm were increased to 5,000 (less than 6% of the total force needed) there would be 80,000 untrained men when the crisis came: if the number were increased to 10,000 there would be rejoicing in the service, but 75,000 untrained men; were the number to be increased to

20,000 the artillery officer would know that the millenium of his life's work was near at hand, but we should still have to face a skilled and trained foe with over 60,000 raw recruits at our guns.

But no one can seriously contend that we should send only untrained men into the forts to reenforce the army. Such a course would be more than foolish. Our safety in case of war will depend upon the efficiency with which the officers and men of this force do their work. The enormous sums which we are spending and propose to spend for ships, forts and guns will be practically thrown away unless we have a sufficient number of officers and men adequately trained to make intelligent and effective use of the guns in the harbor forts. While it would be possible to use in the harbor forts some untrained men, we must have a certain proportion (and the larger this proportion is the better for the country when war comes) of thoroughly trained officers and men. The "Artillery Council," which was convened in 1887 under the authority of General Schofield, submitted a report which treats of many important artillery questions. On the subject of the proper training of artillerymen they say:

"It is necessary to say that all these guns, numerous as they are and formidable as they ought to be, are only buried capital unless they are properly manned. To take a man from the plow and set him to run a locomotive would be deemed criminal by any intelligent man, but the criminality is trival compared with setting him to operate any of the great engines of war, now included in the term cannon. The nation, rich as it is, cannot afford to have untrained artillerymen. It costs on an average over $100 a shot to fire any of the higher grades of guns, and throwing such shot away, as unskilled gunners necessarily must, would be folly.

"It is necessary, therefore, that our guns should be manned, and that our artillerymen should be trained, before either will be worth anything: the guns are useless without the men; the men are useless without the training."

ORGANIZATION OF THE AUXILIARY FORCES.

First. Sea-coast artillery formations should be organized in the national guard or militia, as now constituted in the several states, whenever the states will undertake to do this.

When the time comes to use our new guns against a hostile foe, it will be necessary to send many thousand men into the fortifications.

Ideal conditions would give us the full number of men well

trained in the performance of the work which they would have to do; but this is more than we can hope for, and all that the most sanguine can expect is a system which will supply some officers and men who are thoroughly trained; some who are partially trained, and the remainder—small in numbers, let us hope,—entirely without any training or experience.

But we must know where these men are to come from, under what plan or system they will be enrolled, and how and where those who have preliminary training are to be instructed.

Two general plans at once suggest themselves for accomplishing this result. The first is to leave it for the several states to organize, as a part of their state or militia forces, enough men to supply the deficiency which will exist when all the regular artillerymen have been distributed among the sea-coast forts. If this responsibility is placed upon the states, there are three ways in which they might undertake to meet it.

1. Existing infantry organizations might be trained as artillerymen in addition to their work as infantry.

2. Some of the existing infantry organizations might be changed to artillery, and

3. Existing state forces might be increased in numbers and the new formations might be organized as artillery.

I. The first plan of training existing infantry organizations as artillerymen would be at best imperfect and unsatisfactory. Even in the army where the men can be continuously instructed during the entire period of their enlistment it is impossible to make the same men good infantrymen and good artillerymen. With the limited time for the instruction of the National Guard or State Militia it is not possible to do more than give the existing organizations a sufficient amount of training as infantry, and it would be utterly impossible to make these men good artillerymen in addition.

II. The second plan is open to equally serious objections of another kind. There is no state in which the existing infantry organizations are sufficiently strong numerically to permit of changing some of the formations into artillerymen without seriously weakening the infantry. In fact no state will ever face serious trouble either of a local or national character without recognizing the fact that its infantry organizations are numerically weak. As an illustration let me call attention to the fact that during the recent strike in Buffalo more than one-half of the entire force of the State of New York was sent to that city, and the very grave question at the time presented itself to every

thoughtful man, what would the state have done if the strike had extended to New York, Brooklyn, Albany, Rochester and Syracuse?

III. The plan of increasing the existing state forces and organizing batteries of artillery is excellent in theory, but there is no state in which the numerical limit of the state forces imposed by law, or the financial limitations, imposed by the unwillingness of the people to bear additional taxation, would not preclude the enrollment of an adequate artillery force in addition to the existing forces. It is undoubtedly a fact that there are some states in which additional artillery organizations might be enrolled, and such action on the part of the state authorities should be heartily welcomed and encouraged, but the fact must be recognized that such action cannot under any circumstances result in the creation of an adequate force, and this plan cannot be considered from any standpoint as offering a complete solution of the problem. It would certainly fail to produce satisfactory results if, after the people of the country had invested many millions of dollars in their sea-coast defenses it were left entirely optional with forty-seven different and independent authorities to determine whether or not there should be any men trained to make the defenses effective. It can be safely asserted that such a system would result in some places in having a force inadequate in numbers, and so imperfectly trained as to be practically incompetent. The responsibility would then devolve in time of war, upon the military authorities of the country, of taking this heterogeneous body of men, inadequate in numbers and incompetent by reason of defective training, and of trying to weld them into an harmonious whole for the purpose of resisting the attack of a well-trained and powerful enemy.

Second. A new sea-coast artillery force should be created.

The second plan which suggests itself is that a new force should be organized, either by State Legislature or by act of Congress, or by the combined action of the State Legislature and of Congress. If we are to have a sufficient number of men to form even the nucleus of our artillery force it will be necessary to organize a new force.

We can find in a few lines of the Constitution of the United States the ground-work of the plan which in many respects is the simplest and most practical. That wonderful document, which beyond all other written constitutions has successfully controlled the action of the people for whose guidance it was

prepared, gives Congress the power "to provide for organizing, arming and disciplining the militia, and for governing such part of them as may be employed in the service of the United States, reserving to the States respectively the appointment of the officers and the authority of training the militia according to the discipline prescribed by Congress."

Congress, under the direction of its wisest military advisers, could pass a law organizing the necessary force. The unit would, of course, be the battery, and the number of batteries would be determined by the armament at the different fortified places. The men would be enrolled in their different states, and the officers would receive their commissions from their states.

This would give us the constitutional force contemplated by those who framed the constitution. It would be organized with the clearly defined purpose of protecting the nation from foreign attack, and in the best manner calculated to attain this end. It would at the same time avoid all the objectionable features of a standing army, for it would preserve the characteristics of a state force, with its officers deriving their commissions from their respective states, thus keeping that proper balance between the state and national authorities so essential to the organization of any large force. Such a force would have harmonious and uniform organization without which it could not be efficient, while at the same time the individuality and sovereignty of the states would be recognized.

NEED OF ONE GENERAL PLAN FOR THE ORGANIZATION OF ALL OUR SEA-COAST ARTILLERY.

Third. In order to secure uniformity of organization and harmonious action, there should be one plan or system for the organization of our sea-coast artillery forces, and all the different units of the several forces should be given their proper place in the system.

If we must in time of need use some of our state forces, and have still another force to supplement the army, there must be an organization or system under which these various forces can harmoniously and effectively co-operate with each other. In order to prevent a conflict of authority, and endless and needless confusion, it is absolutely essential that a plan or system should be devised under which these various forces should have their clearly defined and well understood duties and responsibilities. This might be accomplished by the action of the several states, if each state would adopt the necessary plan. But we know that this would be practically impossible, and the only solution is for

Congress to adopt a plan of organization, and give the various component units their proper places in that plan or system.

The vital importance of properly organizing and training our sea-coast artillery force is more clearly understood by the officers of the army than by the members of the state forces or by civilians, and I think that from the Secretary of War and the General Commanding the Army to the youngest lieutenant, all the officers of the army are not only keenly interested in the organization of the force, but are ready and willing to do everything in their power to aid in solving the problem.

EVILS OF CENTRALIZATION.

It is proper here to call attention to the fact that the *organization* must not be confused with the *control* of a force, and it should be emphasized that organization by Congress does not necessitate those evils which result from centralization. Centralization should be avoided. It is believed by many, and I share the opinion, that our present military organization suffers from excessive centralization.

The English and ourselves have both retained the bad features of a centralized system which modern theory and practice alike condemn. General Schofield, in his report of 1887, has pointed out certain evils of this excessive centralization so clearly and forcibly that it is unnecessary to do more than refer to what he has said. Certain defects in the system were clearly shown in the Franco-Prussian war. France had a centralized military organization like our own, and it broke down completely under the pressure to which it was subjected. Their corps, division, and even regimental commanders were obliged to apply to Paris for everything which the force needed in order to fit it to take the field. The military authorities at Paris were distracted by the demands for arms, by questions concerning transportation, where recruits should be sent, how men in one part of France should be got to their regiments in another.

In Germany the organization and preparation had been so complete in each district that the German military authorities were freed from the need of supervising all petty details, and were at liberty to consider how the campaign could be best begun and carried out: they naturally profited by this condition of affairs. Their official account of the war tells that the first orders issued at Berlin were that the army should concentrate on the frontier, but the fact that the French were found to be massing their troops on the same line led to the conclusion that this must

be the result of an organized plan for invasion, which it would be safer to resist with the Rhine as a base, and in consequence the first order was changed. But when it was discovered that the French troops were in the confusion which characterized what might be called their organization on the field of battle, the order was again changed, and the German troops were sent to the frontier, with the results so well known to the world.

If the lesson of that contest is learned, actual warfare will never again present so clearly the contrast between a force like that of France, dependent on a centralized system, waiting for the time of danger to complete its organization, and obliged during the consequent confusion to apply to a central authority for instructions and supplies, and an army like Germany's, with a decentralized organization, complete organization in each locality, and leaders free to make their plans for defeating the enemy, instead of being forced to exhaust their energies in getting their own men ready to fight.

I have referred to this point because I wish it distinctly understood that what I say in regard to the organization of the artillery by Congress does not give any basis for the criticism that it would lead to excessive centralization.

OBJECTIONS TO LEAVING THE ORGANIZATION OF THE FORCES TO THE DIFFERENT LOCALITIES.

Arguments of great force can, in my opinion, be advanced to prove the wisdom of avoiding those evils which would result from leaving the organization of this force to the different states. A sea-coast artillery force is essentially a force for national needs. The guns in the harbor forts will only be used against foreign foes, and the force which serves them will only be called into active service when the entire nation is involved in war; an auxiliary force must do its work in co-operation with the army; the rank of its officers should be such that its units can be assigned to duty with the artillery of the army without disparity in the rank of officers of the army and of the state forces.

The country cannot afford to have the indifference, ignorance, or apathy of certain sections deprive it of the force necessary to prevent its guns and forts in that locality from becoming a mere useless waste of money. And furthermore, the burden of maintaining this force cannot be borne by the states; the greater part of the expense must be borne by the national government, and under these circumstances it is but right that the organization of the force should be such as to insure the ends for which

it is supported. The question of defense against foreign foes is not merely a local one; it concerns the entire nation. It is true that the sea-coast cities have more destructible property exposed to foreign foes than any other part of the country, but in defending the honor of the nation all of the states are equally interested.

I do not believe there is an American in the heart of the forests of Maine who would not wish to have San Francisco amply protected from foreign foes, or that there is a settler at the head waters of the Mississippi who is not in favor of having Boston and New York freed from the danger of bombardment or of tribute to armed enemies.

The burden of protection against hostile foes must be shared by the nation, and by the locality concerned. The Constitution vests in Congress "power to provide for the common defense," and this "power" carries with it the obligation to exercise it fairly and efficiently.

It is not necessary to enter upon any discussion here of the constitutional question, where the duty of the nation ends and that of the state begins. The nation should and will supply the fortifications and armament: the locality must supply the men, or at least the greater part of them. This is made necessary by the fact that officers and men must be trained where the guns are, and that it would be extremely difficult to train men for this work in an inland state.

THE ARMY, THE STATE TROOPS, AND A NEW FORCE, ALL NECESSARY IN THE ORGANIZATION OF OUR SEA-COAST ARTILLERY.

It is inevitable that we shall have to use in our next war, just as we did in our last, three different kinds of troops, viz., the army, the state forces, and a third force, different from each, which will supply the greater part of the fighting force.

I cannot but hope that the system which I have outlined will be deemed to offer a satisfactory plan for insuring the harmonious and effective cooperation of the different forces. It calls for the exercise of no power by the national government which was not contemplated by the men who drafted the Constitution, and which was not exercised in the early history of the country. It does not in any way infringe upon the rights of the several states, and it secures in the only way possible a uniform and harmonious organization of those forces upon which the honor and safety of the nation will depend when we are next involved in war. It provides for increasing the army, but it recognizes the

fact that the largest increase for which we can hope will only supply us with a small percentage of the total number of men and officers. It provides for giving a proper place in our military system to those sea-coast artillery organizations which may be formed in the several states under existing state laws, but which cannot under any possibility supply us with enough men to supplement the army. And it also provides for enrolling and organizing those additional officers and men who will be absolutely necessary in time of danger.

Is it not the part of wisdom, nay, is it not necessary that in time of peace we should decide upon the plan or system in accordance with which this will be done? And even if we do not wish to enroll the troops, we should have a definite and well thought out plan for doing so, and it is inexcusable folly not to do this, now that our new armament is being completed.

SHORT SERVICE, AND AN ARTILLERY RESERVE.

Fourth. All our sea-coast artillery forces should be given a reserve of their own, by adopting the system of short service with the colors, followed by a period in the reserve.

In what follows I shall use the word "Reserve" as describing those men who are called to their places in an existing force, the numerical strength of which it is desired to increase. It will avoid confusion to restrict the word to this meaning, because the army, the militia, and any new force which might be created, should each have its own reserve.

We should give our artillery what all the principles of military science demand that it should have, its own Reserve; this Reserve should be created for the artillery of the army by providing that an enlisted man should be in active service a part of the term of his enlistment, after which he would pass into the Reserve for the balance of his time. During his time in the reserve he would remain subject to orders to rejoin the colors at any time, but would be permitted to return to his home and be free to engage in any occupation. In return for this liability to be called out at any time, he should receive from the government a small sum at regular intervals, say semi-annually.

These men should be required to report in person at certain designated places, to receive this payment, and thus the real numerical strength of the Reserve, and the situation of the men who compose it, would always be known with comparative accuracy. That a certain number of men in the Reserve would fail to report when ordered out, or might attempt to draw their

Reserve pay by proxy while themselves away, is, of course, possible; but failure to report, say once a year, unless absent on leave, or to be present when ordered out, should be treated and punished as desertion.

I have elsewhere strongly urged the creation of a Reserve for our existing state forces. I am of the opinion that it is especially important to adopt this system for the auxiliary artillery force in order to increase the number of trained men who will be available at any time for service at the guns.

This system creates a Reserve composed of men who have been trained as artillerymen by the officers under whom they will have to serve; they do not form an independent force, but when called out they take their places at once in the army, of which they have been, and still are a recognized part. The system increases the available strength of the army, and it makes the strength available in the shortest possible time; and it also enables the country to train more men for any given sum of money, for it must be remembered that the longer the service the fewer men who can be trained for the same cost.

Our military system can not be ideal: it must be what a writer on the same subject in another country has called a practical "approximation to the ideal." Taking into consideration our military needs, and our military and social conditions, and the present relation of our army to the people, I am strongly of the opinion that our military system should have incorporated in it the principle of short service with the colors, followed by a period of service in the Reserve. The adoption of such a system should include proper provision for retaining as long as deemed desirable a certain proportion of long service men, whose presence in the ranks, or as non-commissioned officers is of such very great value to a force.

As the country will not maintain a large force under arms, we must avail ourselves of the best system for increasing the available strength of the army at small cost, and as short service followed by a time in the reserve accomplishes this, we are justified in limiting the length of active service to the time required to turn out an efficient soldier. I do not feel called upon to argue in favor of any specified time, as my contention is for the principle of a short service with the colors, followed by a period in the reserve, leaving to the proper authorities, and for discussion at some other time, the determination of how long that service should be. Short service entails extra work upon the officers and more attention must be given to an officer's

ability to turn out good soldiers: this in itself is an argument in its favor; for there will inevitably be a great many men to be instructed when hostilities threaten, and it is of the most vital importance that we should have as many officers as possible, who are capable of imparting the knowledge which they possess.

Among the advantages of the system of short service is the fact that it would increase the numerical strength of the artillery, although only a small number of men would be under arms at any one time, and it would do this in the most economical manner possible. If, for example, we have 5000 enlisted men, and have them serve two and one-half years with the colors, and then pass them into the reserve for the same length of time, we should have 5000 men always with the colors, and 5000 additional in the reserve. These additional men, if paid $12 per man per annum, would cost the country $60,000 yearly, or if paid $24 per man, $120,000; and estimating that the men in active service receive $156 per annum, or a total of $780,000, we would practically double the size of our artillery, or at least double its available strength by an increase of from 8 to 16% in our expenditures; this does not include an estimate of the expense of uniforms, arms, etc., nor does it take into account the saving in rations, etc. If the time of active service were reduced to two years, with four years in the reserve, we should have 5000 men with the colors, and 10,000 in the reserve, thus increasing the available strength of the artillery 300% by an increase of from 16 to 32% in expenditure.

The figures which I have given are but illustrations of what can be done under this system; the amount paid the reserves, and the length of active service and time in the reserve, being the factors which determine the expense.

I do not think that the "money argument" should be given more than its due importance, but the difficulty of getting suitable appropriations from Congress lends an interest which is not diminished by the fact that our army is relatively to numbers the most costly in the world.

Our army is limited in size by the will of the people, and we are apt to feel that our military power is therefore irreparably weakened: but the system to which I have referred offers a way, with comparatively little additional expense, of increasing our available strength to almost any size we may desire, and of infusing into the people a large proportion of well-trained serviceable men who would be of the greatest value in an emergency.

It is not without interest that this system of short service and reserves was the result of Napoleon's effort to weaken Prussia after the peace of Tilsit, by limiting her army to 42,000. General Scharnhorst, King Frederick William III's Minister of War, whose genius has left a lasting impress upon the Prussian army, adopted the principle of short service, passing the men into the reserve and continually taking new men, so that in a few years the nation had many thousand trained men, who were able at Leipsic to avenge Jena, and prove the value of the system which has now become almost universal.

THE TERRITORIAL SYSTEM.

Fifth. The territorial or localization system should be adopted for our sea-coast artillery forces; the country should be divided into artillery districts, aud the force in each should be recruited chiefiy from men located in the district.

The territorial system should be applied to all our armed forces; it has been adopted by almost every country but our own. It consists in subdividing the large military districts, such as our present military divisions, into smaller districts, each of which has its own military unit, either regiment, brigade or division, the unit being recruited from men living in its district.

This is not the place to point out its advantages for our infantry organization. So far as the sea-coast artillery is concerned, it is sufficient to say that this system is essential to the organization of a reserve which can be satisfactorily maintained in time of peace, and numerically increased with well trained men in time of war, and rapidly mobilized. As we can never expect to keep any force in time of peace sufficiently numerous to do the work which must be done in time of danger, and as modern warfare means rapid preparation, we must adopt the territorial system, and organize a reserve if we intend to be in any degree prepared for war when it comes.

NEED OF SUFFICIENT NUMBER OF WELL TRAINED MEN AT SHORT NOTICE.

Sixth. All the sea-coast artillery forces should be organized and trained with a view to suddenly calling into the forts enough men sufficiently well trained to make the guns effective against a foreign foe.

It is of the utmost importance that in the organization of an auxiliary artillery force, whatever may be the plan or principle followed, we recognize at the outset that the force must be enrolled and trained with the clear understanding that it is a fighting force. Opinions differ to-day regarding the part which our existing state forces would take in case of war, and no one knows

exactly what they would be expected to do. There must be no doubt of this kind about our artillery force; officers and men must be ready to go to their places at the guns when the first hostile ship appears, and to stay there so long as danger threatens. The force must work and fight in co-operation with such officers and enlisted men of the army as are sent into the forts with them. This force should be just as much a part of our national defense as the army or navy, and its members should receive from their fellow citizens that consideration which is due to men who, for love of country, or from a sense of duty, voluntarily consent, at the risk of their lives, to repel foreign invasion.

The character of the attack which, in case of war, would be made upon us, has often been described by military authorities. The danger which threatens us is an attack on our sea-coast and the capture or ransom of one or more of our large cities. No nation would attempt the conquest of our vast territory. The fact that during the rebellion we waged a war for four years and maintained a million men under arms, has proved to the satisfaction of the military authorities of the world that the conquest of our country is impossible. No nation or nations could maintain, so far from their base of supplies, a force sufficient to attempt such a task. Our vulnerable point is our coast, dotted with rich and populous cities. These cities would be the first object of attack when we are involved in war with any foreign nation, and their capture or ransom would entail a money loss and a national humiliation doubly unpleasant to consider, since we know that if attacked, we are, at the present time, unable to avert these calamities. It cannot be too strongly emphasized that our enemies would act upon the admitted principle of modern war, that attacks must be sudden; that the foe must be overwhelmed with a well organized and efficiently trained force at the outset; and that the beaten side must pay the expenses of the contest, consequently, our defense is not complete unless we are able at short notice, to resist such attacks. A few months would probably be too long to count upon for preparation, and as we cannot secure in time of peace a single modern heavy sea-coast gun in less than eighteen months, and as one year is the shortest time which any military authority has ever named for properly training a force of artillery, the futility of relying on what we can do when war threatens is apparent.

A deliberate determination to remain unprotected could only be founded upon the delusive theory that war is impossible, or

upon the mistaken idea that if it comes we can prepare for it when the danger threatens. War is possible, and it is the part of wisdom, as well as sound business economy, to insure ourselves against it: the fallacy that we can prepare for war at the outbreak of hostilities, rests upon such utter ignorance of the conditions of modern warfare that it need not be discussed here. It may be stated as a proposition admitted by every one who has the slightest knowledge of the subject, that years of work and millions of dollars will be needed to secure defenses suitable to meet the attack of even second-rate powers.

APPOINTMENT OF COMMISSION BY CONGRESS.

In what precedes I have referred only to broad principles. It will of course be evident that a multiplicity of important details will arise, while an attempt is made to apply these or any other principles to the organization of our sea-coast artillery. It is important that the questions thus presented should receive the most careful consideration, and that the plans adopted should be in harmony with the sentiments of the people, and at the same time conform to the needs of the service; these results could probably be best secured by the appointment of a commission, under authority of Congress, which should be charged with the duty of submitting a report, giving in detail the plan for the organization of all our sea-coast forces.

CONCLUSION.

Let it not be supposed that the army or the navy, or the civilians who wish to see our coast defended, want war. Every sane man knows that its horrors are beyond words, and that the suffering which it entails is not limited to the field of battle, but blights the homes all over the land, where sorrowing widows and orphans and helpless cripples feel its pangs through the lapse of long, weary years. It is because war is so terrible, and because adequate preparation reduces the chances of our having a war, and lessens the cost and the suffering if it comes, that we should have the best possible organization of our forces.

If our army were to be abolished; if the state forces were to be reduced to a handful of men; and if our navy were to become a mere coast guard, we should still have a carefully thought out military plan or system for the organization of those forces which necessity would compel us sooner or later to call to arms.

I have written in the hope that if the suggestions which I have made regarding the organization of a sea-coast artillery force do

not meet with the approval of those whose opinions will determine what plan is eventually to be adopted, the ideas which I have expressed will at least serve to call forth some better plan for protecting the national honor and the lives and property of our citizens.

In conclusion I may be permitted to repeat what I have said before: "No great nation has so simple a military problem as America. We have no jealous or threatening neighbors. We have no inherited race quarrels which have been such potent factors in hastening war. We are, by reason of our great numbers and vast territory, absolutely free from all dangers of a war of conquest. Our only need is that we should be in a condition to discuss international questions with foreign powers without having our greatest cities and their vast wealth and commercial interests absolutely at the mercy of those powers. While we can easily afford the money loss which the ransom or destruction of our sea-coast cities would entail, we cannot afford to undergo such a needless humiliation. If, neglecting all proper precautions, we should suffer disastrous defeat, and national pride should then tempt us to undertake what would really be a war of revenge, we might possibly find that such an avowed purpose would array against us a combination which the most sanguine would not be pleased to encounter; and such a policy, even if successful, would entail an expense so enormous as far to exceed the cost of maintaining a proper and adequate system of defense. If we offer no vulnerable point to possible enemies, any position which we may take in regard to international questions, or any demands which we may make, will be carefully considered; and if our claims are disregarded we shall then be in a position to determine what course of action we should adopt. If, as some people hope, this country is to exert upon the world the beneficent influence of a great people raising their voice only for what is right, that influence will be strengthened and widened if we add to our admitted wish for peace the unquestioned fact that we can resist and punish any attacks which foreign nations, in the excitement of some controversy, might be tempted to make upon us."

NOTES ON CONFEDERATE ARTILLERY SERVICE.

By Professor M. W. HUMPHREYS, University of Virginia.

[CONCLUDED.]

Though the prime object is to state our experiences, still some general remarks will be made in this article to make clear the principles illustrated.

We first take up the selection of position as determined by topography, position of other troops, etc. Past experience, in this as in other respects, has lost much of its significance through the improvements of guns and the introduction of smokeless powder. We hear much about completely concealing batteries and even firing from behind forests and hills. But despite all this, there remains one consideration which the artillerist cannot afford to ignore: the enemy must not be allowed a resting place in close proximity to our guns. Whether small arms or cannon are to be relied upon to sweep the immediate front will be decided by circumstances; but the possibility of infantry yielding before an onset must not be disregarded. Even after such a reverse rapid firing guns may well retrieve the day if they command the space close around them. The experience of the artillery with which I served bears but little upon this subject. During the battle of Cloyd's Farm (or Mountain) many of the Federal soldiers at a certain crisis of the engagement literally *fled toward us.* That they were not advancing against us was perfectly obvious and is shown by Federal official reports. This remarkable phenomenon resulted from the fact that the space behind the lines, when they were dispersed by our fire, was exposed for a considerable distance, while close in their front was a large space completely sheltered by the hill on which we were posted. The men that ran forward afterwards aided in turning our left flank when it had been weakened by the withdrawal of part of that wing. One of the books we used urged the importance of placing guns so as to command the slope in front, and went so far as to say never to fire from behind the crest of a hill. Another work advised that the firing be done from behind the crest of a hill or anything else that offered protection. The latter plan is, of course, the better, provided the

dancing of the air close to the ground does not impair the aim and the space in front can be immediately swept at any time by moving the guns a very short distance forward. At Lynchburg, June 17th, 1864, when our force was still quite small, we were throwing up works on a hill very near the city and leaving the slope in front entirely without fire, when an officer (as yet unknown to me) rode up and called our attention to the danger we were incurring in case of attack and advised us to move forward some distance, but remarked that the battle would probably not be fought there. He turned out to be an artillery officer of Early's corps which was just arriving in the city.

The question of position with reference to other arms was an almost constant embarrassment to us. Our ammunition was such that to fire over our own men was extremely dangerous. I have seen casualties inflicted in this way repeatedly. In fact our infantry, when posted in front of artillery, has been known to climb over a stone fence to the enemy's side. The U. S. Army will never use such guns and such ammunition as ours were, but still there will always be some danger or a sense of danger; and besides, the passage of a projectile near a person at a short distance from a gun causes a sudden, harsh noise which almost produces a shock, and if the gun is very close there is a real physical shock. We found also (what onyone could foresee) that behind artillery is a bad place for infantry. Still we often posted men behind batteries. Thus the 36th regiment Virginia Infantry was posted behind Bryan's battery at the battle of Cloyd's Farm, and the 45th Virginia battalion was strangely posted in an open field behind the guns during the artillery duel at New River Bridge on the next day. But after we were incorporated into Early's army, this was done only in cases of necessity, or when the infantry was thoroughly sheltered. At the battle of Castleman's Ferry (July 18, 1864), after our battery had by a laborious march secured a good position, it was actually required by a major general to go to the rear lest its fire should attract that of the enemy to the annoyance of the infantry in a woodland behind us. It was with difficulty that, after a long detour, we found a position from which we were allowed to fire. It is obvious that a plan of battle does not descend to minute details, when an important battery has to play "Poor puss wants a corner"; but this aspect of the case does not belong here. To exhaust our experiences bearing on the general subject of relative position to other arms would be to write a detailed account of nearly every battle I witnessed.

Different from either of the foregoing subjects is the selection of positions with reference to the general topography of the field. It is impossible, without topographic maps to illustrate most of our experiences. We sometimes committed errors. At the battle of Fisher's Hill our artillery was nearly all on the steep bluffs on our right wing where it would have been impossible to carry our position by direct assault even if we had had no artillery there at all. Whether it was possible to post artillery further to the left without making a road for it, I cannot say; but it was sadly needed there while it lay idle on the right.

At the beginning of the war "Gauley Bridge" (at the confluence of the Gauley with New River) was universally regarded a the "Key to Western Virginia"; but a little experience showed it to be simply a trap. I did not, however, witness any of the operations there.

On May 21, 1863, our battery and a brigade of infantry, having retired on the previous day from before Fayetteville, passed Raleigh C. H. late in the afternoon. My piece (a 12-pdr. howitzer) was sent back to the hamlet with some infantry. The piece was placed in position beautifully commanding the road for some 400 yards to the brow of the slight plateau on which we stood. Presently a concussion shell struck and exploded within a few feet of the cannon (mortally wounding a little girl, by the way, who was standing near us). The shell had been thrown from a mountain top far beyond the range of the howitzer, and there was nothing left us but to limber up and ignominiously gallop off with shells bursting about us.

Connected with the foregoing topics is that of coming into action; but as the Federals were the assailants in most engagements witnessed by me, I cannot contribute much to the subject. On one occasion the caissons and sergeants' horses were left behind, and the cannoneers ordered to "mount," though there were seats for only three to each piece. Then came the amazing order, "Forward—*gallop*—march!" The horses galloped and the men ran about a quarter of a mile. The condition we were in needs no description. It is just, however, to state that the battery on this occasion was rushed into action thus suddenly lest a few cavalrymen in our front might get out of sight before we could waste some ammunition on them.

There is one consideration which, it seemed to me, was greatly neglected by us, though it is possible that the neglect was sometimes not so great as it seemed. I refer to the failure of artillery officers to acquaint themselves with a prospective battle

field, and the neglect of those in high authority to give artillerymen necessary information as to the situation of affairs during the progress of a battle. Even when we were awaiting an attack, and actually when we were in fortified posts, I never knew of any requirements that the artillery officers or gunners should acquaint themselves with the nature of the ground before them or to measure the distance to any points on the field. Such neglect was not at any rate universal in the Federal army. On one occasion, when we approached a fortified place, my piece went first into battery some 1300 yards from the nearest Federal gun and fired a shot. In a few seconds a projectile passed between my axle and the ground. With the sequel we are not concerned; but I afterwards discovered that we were within a few feet of a target that had been shot to pieces. The importance of being thus acquainted with the field is so obvious that it seems absurb to allude to it; but our neglecting it shows that it needs to be insisted upon. Ignorance of the ground sometimes caused guns to be placed in positions, good enough in themselves, but such that it was not possible to advance from them or to retire by another way. The question whether guns should *ever* be placed so that they cannot be withdrawn in case of disaster hardly belongs here; but I will say that my observation and experience convince me that artillerymen are demoralized more or less by being thus placed, and those immediately responsible feel a constant embarrassment as to the course to be pursued in case of a reverse.

It is evident that the topography cannot be known to too many; but how far down the official scale should a knowledge of the disposition of troops and the progress of the battle extend? And should the *men* ever be informed of what is going on about them? In the early part of the battle of Winchester (September 19, 1864), when Wharton's division and King's artillery battalion were entangled with the Federal cavalry far out on the Confederate left, Bryan's battery went into position to arrest the advance of some cavalry on a road. No other Confederate forces were in sight except a small command of cavalry retreating in confusion past our guns. There was heavy firing, however, in almost every direction. Just as our pieces commenced firing a field-officer rode up to give instructions to the commanding officer. When he was departing, I approached him, told him in a word why I ventured to do so, and asked him to give me some idea of the situation of affairs. He was utterly amazed at my "effrontery" and severely rebuked "a mere sergeant" for daring

to ask such a question. The reason I had assigned was that I had been placed in charge of the caissons and ordered to keep them in as safe places as possible within 200 or 300 yards of the guns and to conform my movements to the progress of the battle. Under these circumstances it does not seem that a commission in my pocket would have materially modified the case. Soon after this I was ordered to the guns, some one else, equally in the dark, taking charge of the caissons,—and we saw them no more till after the day was lost. A charge of cavalry in our rear swept them into Winchester, and at the most important crisis of the battle, when Gordon's division had yielded, Bryan's battery suddenly ceased firing for want of ammunition. The situation really made it imperative that the caissons, whatever might be their exposure, should be kept nearer the guns. Again, after the battle of Winchester and Fisher's Hill, when our army was making a running fight past New Market, I was entrusted with the caissons of Bryan's battery. As we fell back, conforming our movements to those of the pieces, we arrived at a place where a road led off towards Port Republic. Just then a cavalryman (who did not despise sergeants) informed us that the Federal cavalry was at Harrisonburg in our rear. The battalion chief of caissons (who, by the way, was also a sergeant), leaving me in command of all the caissons of three batteries, went away to get instructions. Before he returned the pressure of the Federal forces from the direction of New Market made it absolutely necessary to move the caissons. Observing that the wagon trains had taken the Port Republic road, I followed them. Had not a private horseman informed us of the situation, the caissons and ammunition of an artillery battalion would have been lost, and even as it was there was a serious dilemma with the possibility of fatal error. On one occasion there was an exception to the usual secretiveness of high officers. At the battle of Piedmont (June 5, 1864), when it became evident that the Confederate left could not stand its ground on account of being far in advance of the right, General William E. Jones, who was in command of the entire force, conducted two guns (mine and another) from the right flank of the left wing to the extreme left. When we reached that position our lieutenant was missing, and Jones explained to me as ranking sergeant the exact situation of affairs, and his plan for the rest of the battle, which was to withdraw the left wing into alignment with the right, and we were to canister the Federal flank if an attempt was made to press our retiring line. This

movement was not executed because Jones was killed soon afterwards; and when our infantry at last yielded, the sergeants, waiting in vain till the last moment for orders, succeeded in extricating the guns from the very presence of the enemy.

As to the propriety of letting even privates know anything more than they see with their own eyes, the question is different. Officers need information, that they may act with intelligence. In the case of privates there could be no use for such information if a soldier were a machine subject solely to the will of those controlling it, and not liable to different degrees of efficiency. But this is never the case. It was probably further from being the case in the Confederate army (where, it was said, all were "major-generals") than in any other army that has ever existed; but in every army the private must be more or less influenced by what he conceives to be the true state of affairs, and I have often known our men to be disheartened and rendered timid by a misconception of the surroundings, and do not recall an instance of the contrary. The sole objection, then, to imparting such knowledge to inferior officers and men, would seem to be the danger of captured men giving the enemy information. This subject, however, is not peculiar to artillery.

We now pass to a different subject. In any battle whose issue is doubtful or inevitably unfavorable, an artillerist is liable to find himself in constant uneasiness as to what he is to do with his guns. Infantry and cavalry may manoeuvre, retire, advance, or retreat finally from the field; but artillery is much less flexible. If a field battery allows itself to be closely pressed before retiring, it is likely to lose some of its pieces through horses getting killed or injured. This uneasiness is most liable to occur in small armies or detached forces. It was sometimes my fortune to be placed on picket with a single piece. On such occasions I was embarrassed even before any enemy appeared. The picket was always under command of an infantry officer who, sometimes, cared little and knew less about the difficulties the artillery was likely to experience in case of a sudden dash of a superior force of cavalry. One of the works on artillery, which we used, says it is never safe to operate with less than two pieces. We found that even two pieces offered no guarantee of safety, and might fail to do any good whatever. On May 23, 1862, Heth attacked Crook at Lewisburg, W. Va. To protect his retreat, in case of defeat, across the Greenbrier river, he left two pieces of Bryan's battery on a hill near the bridge. The

battle proving disastrous, the Confederates came back in confusion closely followed by the Federals, and the two guns which had been placed on the hill to be ready for just this contingency, were withdrawn without firing a round, lest they should be captured. Who was responsible for this is a matter of dispute to this day. The opposite extreme is illustrated by the battle of Fisher's Hill, where the Confederate artillery held its ground so long that the Federal right struck it on the left and rear and captured eleven pieces. The day was already irretrievably lost, and the artillery could have done better service by retiring earlier and instituting a running fight. What is the proper mean between these extremes? This question cannot be discussed here. So varied are the conditions which may arise that it is impossible to formulate any general rules. The question may arise even whether it is not better simply to sacrifice certain guns, men and all,—that is, whether the good accomplished by firing the guns to the last may not more than compensate for their loss and the consequent bad moral effect. In this instance the artillerymen would probably not be impartial judges; but the question is one that somebody must decide, and that not rarely. In this matter I have both made observation and had experience.

At the battle of Cloyd's Farm the Federal infantry was within seventy-five yards of some of the guns when they were withdrawn. Two were lost, but one of these could not retire because of the nature of the ground behind it. These are probably the guns of which Lieutenant-Colonel Comly (23rd Ohio Volunteers) says in his official report: "The struggle at the guns was of the fiercest description, the artillerymen attempting to reload when our line was not more than ten paces distant. Lieutenant Stevens shot one of the gunners at that distance."

At Winchester (September 19, 1864) the Confederate artillery struck the proper mean, and, after accomplishing all that was possible, came off with very slight loss of guns. The handling of our pieces on that day was described in my previous article. One incident may be added. When retiring through the town, we found the caissons of our battery, and replenishing the limber chest of one piece to which I had been assigned, we posted it on the hill to the west of the town and continued to fire until the Federal cavalry had gone far past us on the main pike. It was already dusk when we ceased firing. Captain Bryan remained with us and directed our movements. Whether he expected to escape or not, I do not know. We certainly could have been captured, but were permitted to escape on the

"middle road," and rejoined the main army on the next day as it straggled through Strasburg.

At Cedar Creek (October 19, 1864), when the tide of battle turned against the Confederates in the afternoon, I saw a battery remain in position and fire on until it caused a hollow wedge in the Federal army as it passed by on each side. No attempt, I think, was made to withdraw these guns. Strange to say, there seems to be no mention of this in official reports. It is not possible to determine whether this hopeless stubborn resistance yielded any adequate results, but it appears probable that some artillery and wagons, that were subsequently captured through the breaking down of a bridge, were, by the sacrifice of the guns named and some others, making good their escape.

At the close of this battle, for reasons mentioned in my previous article, Bryan's battery retired from the field with ammunition in the limber chests. This battery was among the last to leave the field; and when we had crossed Cedar Creek and were ascending from the gorge I was sent with one gun to occupy a little knoll to the west of the road and overlooking the gorge, and to prevent the enemy from crossing the Creek. Two other guns from other batteries joined me, but retired at once, seemingly for want of cannoneers. The orders given me were explicit enough: "Sell the gun for all it will bring." It did not bring much. The details of what followed do not belong here. The sum of it was that we fired two or three rounds; the three cannoneers that had stuck to the piece escaped, one driver was killed, and the gun and horses with the drivers and myself were captured, but I immediately escaped with my horse in the gathering darkness. This affair did not give me a high opinion of "forlorn hopes." The sacrificed gun certainly did no good, unless possibly the storm of projectiles it attracted kept the Federal cavalry off our trains for a time.

The question when to fire and what to fire at very often embarrassed us. This was due in great measure to the fact that our ammunition was usually scarce, and that we were frequently by special order restricted in its use. Sometimes the order was quite specific to fire only at advancing masses of infantry. Our course was then plain: to let the Federal artillery make targets of our guns and practice at its leisure; or to let small bodies of sharp shooters annoy our gunners. Sometimes the order was to be specially sparing of ammunition, and it was always understood, of course, that we were not to squander it. But in spite of these facts we often fired uselessly, and there is no need to

insist that useless firing is always worse than useless. I mention a few out of many instances. Our firing at trunks of trees, distance unknown, was mentioned in a former article. At New River Bridge (May 10, 1864) we fired a *salvo* from a dozen guns at one piece (the first to get into position), although our only hope of saving the bridge was to use our ammunition sparingly and hold the position until reinforcements could reach us. On the same occasion a 20-pounder Parrott was fired at a single man who had gone out into an open field and seemed to be viewing us through a glass. We "wanted to see him run," which, by by the way, he did not do, but stood perfectly still, although the projectile struck very near him. At Lynchburg (June 18, 1864) there was an incident that seems to deserve special attention. The artillery duel had ended in our favor, and Bryan's battery was shelling almost everything that showed itself on the Federal side. An artillery staff-officer of Early's corps came to us and told us not to fire except under certain conditions that he mentioned, and remarked that every time we fired we disturbed our own men as much as we did the enemy. We informed him that we had just loaded a piece, and asked permission to fire it at a squadron of cavalry passing our front. He told us to fire and to "*listen* at the effect on our own men." We fired, and instantly *a rattle of musketry passed along our line.* He then, with the tone of one that had often witnessed the phenomenan, said: "Do you hear? Every time you fire our men think *there they come!* and bang away at nothing." On the night of July 7, 1864, Early's army, leaving the Federal force on the Maryland Heights behind it, moved towards the passes leading to Frederick City. The next morning Bryan's battery was placed on the rear guard, which remained where we had bivouacked until the army had got well started, as we expected to be annoyed in the rear. While we were still there a Lieutenant-Colonel of artillery, seeing the partly burnt trunk of a large tree at least thirty feet tall (my diary says "about fifty") some 800 yards from us, insisted that it was a "Federal officer" (privates do not grow so tall), and had us fire two rounds at it. As the second round knocked large pieces of timber out of it and it neither fell nor ran, he admitted his error and remarked: "Well, I wanted anyhow to let them know we are about." To say nothing of waste and wear, this firing not only very unwisely "let them know that we were about," but also of course caused uneasiness in our whole army. At the battle of Winchester during the fights with the cavalry on our left early in the day, one battery of our battalion fired away all

its ammunition and left the field for good. Analogous instances might be multiplied.

The Federal artillery, being better supplied with ammunition and getting new guns when needed, could afford to fire more freely; but even they sometimes did unjustifiable firing. During the time (July 6-7) that we were under the Maryland Heights, the great guns on the mountain fired many rounds apparently at small groups of men if not at individuals. When we were before Washington, being sent to seek grain I saw a corn-crib near a house on top of a hill in front of Fort Stevens, and rode to it. There I paused to view the scene before me, whereupon a very large projectile passed close by me. The situation was such that there could be no reasonable doubt that the shot was fired at me.

There is a matter of special importance in which our experience may be worth something. At sufficiently short intervals we had regular inspections of *matériel* and *personnel*; but these inspections were purely formal, and I never knew them to discover any defect, unless it was an unboiled shirt (when we had shirts), or something of equal importance. More than this is absolutely imperative. The inspection of the *matériel* should consist in the closest scrutiny of minutiae and in actual tests of efficiency. In the early spring of 1863 it was reported that a Federal force was approaching the all-important salt-works in south-west Virginia. A small force of infantry and several pieces of artillery were sent to meet them, and took position at a point where the artillery, protected from sharp-shooters by the infantry, was supposed to be able to drive the Federals back. Fortunately for us they did not come. A few days after this, when we tried the guns (not to find out whether they were in working order, but to ascertain how accurately they would shoot), with the single exception of a howitzer all the guns we had depended on as stated above were disabled in some way by the very first discharge. On another occasion, at a critical moment, we found that not more than one friction-primer in half a dozen would explode. At Piedmont (or New Hope, June 5, 1864) half the shells exploded in or at the muzzle of my piece. At Cedar Creek (October 19, 1864) at the crisis in the morning when the Confederate artillery was massing, the best gun in Bryan's battery was discovered to have its vent so enlarged that the piece was useless and was sent from the field. During the rapid firing after the guns had been massed, my gun leaped from the trunnion-beds and lit on the ground some twenty feet behind the carriage. When we had remounted it I discovered (what I

ought to have known before) that the pins which secure the trunnion-keys were wanting. I cut one of my shoe-strings in two and secured the keys, it is true, and we fired again within a minute after the round that dismounted the gun; but this promptness was the result of three years' drill and experience, and the consequences might have been very serious. On November 22, 1864, during very severe weather Sheridan sent a large cavalry force to reconnoiter, and not half the guns in Early's army were able to move because of frozen harness, immovable wheels, &c. On the same day when the Federal cavalry on Meem's Bottom confronted us on Rude's Hill, a gun near mine discovered that it had no friction-primers and had to borrow from mine. These are a few of the many illustrations that might be cited. The importance of this subject has been rather increased than diminished by the changes that have been introduced in artillery since that time.

As Bryan's battery used many different kinds of pieces, a word on the best size for field purposes seems appropriate. Our two best guns were in some respects, and for opposite reasons, also the worst. These were a 3-inch rifle weighing only 500 lbs., and a 20-pounder Parrott weighing 2000 lbs. Both these guns were accurate and comparatively long-ranged, but the former, because of its lightness, could never be trusted with confidence to do anything but break its carriage or kick loose in some way, while the latter, because of its weight, was a constant annoyance on the march and on the battle-field, coming to a stand-still in every mud-hole and on every steep grade. We used eight horses with this gun, with no avail. It is impossible to render serviceable for an active campaign a piece which weighs, carriage and all, as much as a 20-pounder Parrott. Still, the superiority of this gun over other field pieces used during our war is notorious. Once in position its moral effects were equal to those of two or three guns of smaller caliber. There is a peculiar harshness about the sound of its projectiles that makes it well worth studying and imitating; for there is no doubt that guns can now be made (as I believe they are made) equal in other respects to the 20-pounder Parrott, but much lighter.

In my first article there were mentioned several other subjects on which our experiences would throw some light; but I am not able to give any useful account of those experiences for want of needful knowledge of the subjects themselves, such, for instance as the care of horses, and the preservation of harness. I will add that our experience would be of no value in considering

how and *what* to fire. With us every gunner fired when he was ready (usually before he was ready) and used what ammunition he pleased. It was my own habit to use case-shot at all times, even in preference to canister at close quarters, sometimes cutting fuses of certain kinds at zero, which caused the projectile to explode several paces from the muzzle of the gun. Of course under these circumstances it was often difficult for each gunner to identify his own shot and so obtain the range.

As the war progressed the artillery took more and more active part in engagements. At the beginning infantry "supported" artillery; at the close artillery fought independently, manoeuvred more freely than before, and sometimes "supported" infantry. The growth of the importance of artillery despite the drawbacks to such growth, would form the subject of a useful study for some one capable of the task. The next war (if we ever have one), it may be remarked, will not give us two or three years of preliminary training and experience, but it will be serious business from the start.

In closing these articles I wish to say that it has not been my hope to show how to do anything, but I trust the facts detailed will show how *not* to do some things, which will be found a matter of no small significance in case of war with a great power.

WIND COMPONENTS.

By First Lieutenant ALBERT TODD, First Artillery.

The method of computing wind components described by Lieutenant Davis in the last *Journal** is a great improvement on the present method, but it is capable of further simplification by the following device.

The dial board is divided into sections similar to those shown by Lieutenant Davis, but each diameter is divided into twice as many parts as the maximum number of miles of wind usually obtaining in firing practice. Probably sixty divisions would be ample, for thirty miles of wind. The radius of the divided portion of the dial need not be greater than fifteen inches.

The lines parallel to the XII, VI diameter of the dial will be the sines, and the others the cosines of the various angles and of course will measure the components. The lines showing deviating components should be painted in one color and the accelerating or retarding in another. The XII, III, VI, and IX points only should be marked on the dial. The abbreviations "Re", "Ri", "A", and "L", might be used for "Retarding", "Right", "Accelerating", and "Left", respectively, but the clock notation is believed on the whole to be simpler. The lines should be marked at convenient intervals with their component values.

The other part of the device is an arm with sliding index firmly attached to the vertical rod carrying the wind vane. This arm is the same length as the radius of the marked part of the dial, and is divided into parts for each mile of wind.

To operate, when the force of the wind is sent from the anemometer, set the index at the reported wind, turn the XII–VI line in the direction of the target and read off the component from the line nearest the index.

It would probably not be necessary to draw the component lines for more than the even (or odd) numbered winds, for the others could be readily interpolated by the eye.

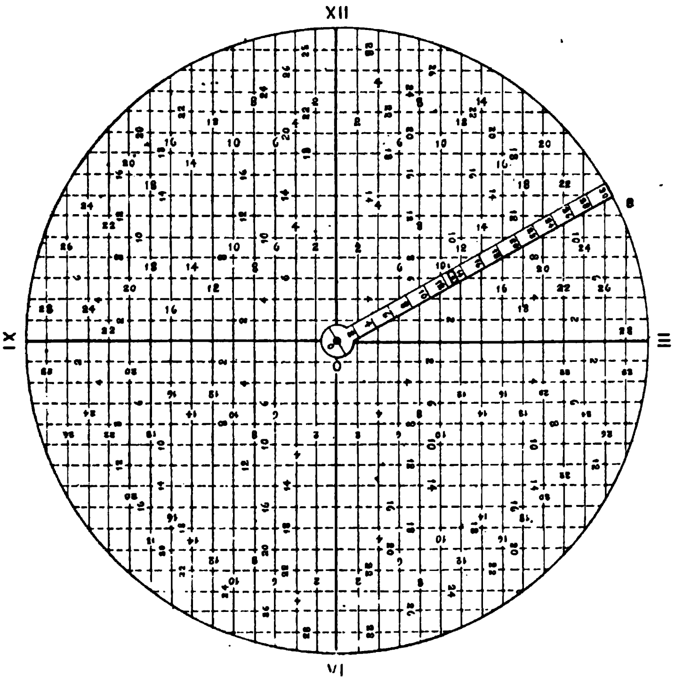
By the method above indicated, absolutely no calculation, mental or otherwise is needed, the only precaution required being to keep the index set to the wind indicated by anemometer.

* Volume IV, No. 4. October, 1895. Page 664 *et seq.*

The apparatus is easily constructed ; can be made at any post by the ordinary mechanics. The arm can be put on with a set screw so that it can be removed when not in use.

The accompanying figure will aid in understanding the above description.

Fig. 1.



O B is the arm attached to the vertical rod of the vane.
i is the sliding index, the point, of course, being under the arm.
In the drawing, the arm is out of proportion in order to show its figures distinctly; only *even* winds being written for same reason. The broken lines and their figures are red in the apparatus itself.

The following ready means of finding points allowance for wind and drift combined may be of interest to some.

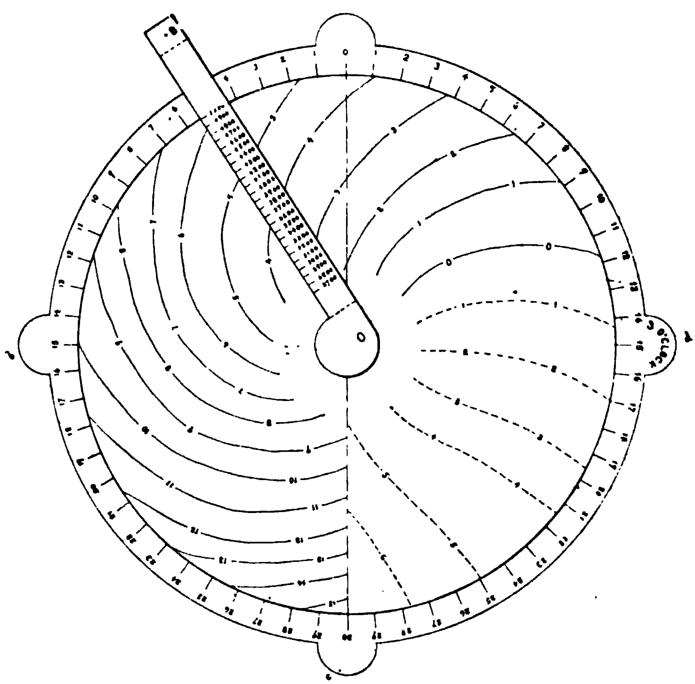
A circular zinc or tin disk about 14 inches in diameter has its semi-circumferences divided into thirty equal parts corresponding to miles of wind up to 30, one side for 3 o'clock and the other, 9 o'clock winds. For purposes of construction, diameters are drawn through these points. Commencing a convenient distance from center (in the one made by me 1⅜ inches) concentric circles are drawn with radii corresponding to different ranges of gun. In my apparatus, ranges at intervals of 100 yards from 2700 to 5000 were considered. These circles are also only for construction purposes.

Now taking any particular gun and initial velocity (I took 8" converted rifle, I.V. 1330), the deviations and consequent points allowance for wind and drift combined are calculated for all winds from 1 to 30, both 3 o'clock and 9 o'clock, and for all the ranges considered. Now going to the disk with its intersecting circles and radii, the points of allowance can be readily plotted.

Connecting the points of equal allowance, we have the curves of equal allowance. These are painted on the disk, which has already been painted white in the 9 o'clock semi-circle, and pink or any other light color in the 3 o'clock semi-circle. At convenient intervals the curves are marked with their values. All construction lines are now erased.

This disk is pivoted on a board, and at the same pivot is attached what may be called a range indicator. This is a strip of hard wood or metal on which are laid off distances corresponding to the ranges considered. This indicator is solidly attached at its outer end to the board, and being longer than the diameter of the disk and thicker at the ends than in the graduated portion, the disk revolves freely beneath it.

Fig. 2.



O B, Range Indicator.
a, *b*, *c*, *d*, Handles.

To operate, when the wind is reported, which by the above mentioned device (Fig. 1) will always be in normal components, the disk is revolved till the reported wind is brought to the edge of the range indicator. Then the curve nearest to the range under consideration will show the points allowance to be taken, and whether right or left, curves of allowance to left being painted in black and to the right in red.

By having disks for four or five different strengths of powder, and also different ones for different kinds of guns, which may be slipped in when needed, the device is of universal application, for the range indicator may be graduated for all ranges used.

The same principle may be applied for indirect firing, points allowance being changed to minutes on azimuth circle to be added or subtracted.

This device also is easy of construction, so far as the mechanical work is concerned, though the calculations are of course somewhat tedious.

The accompanying figure shows the construction. The little semi-circular protuberances are simply to facilitate revolving the disk, being slightly turned up.

The writer attaches no merit to either of these devices save as they do away with figuring, and thus abbreviate work.

GENERAL BALLISTIC TABLES FOR MORTAR FIRING.

BY JAMES M. INGALLS, CAPTAIN, FIRST ARTILLERY, INSTRUCTOR ARTILLERY SCHOOL.

When the muzzle velocity of a projectile does not exceed about 900 f. s., the resistance it encounters from the air in its flight is sensibly proportional to the square of the velocity; and even when the muzzle velocity is as great as 1200 f.s., the departure from the quadratic law of resistance is so slight as to produce no material error in the range, time of flight or striking velocity of a projectile computed by Euler's Method and Otto's tables, both of which assume the quadratic law.* The following application of Otto's tables to the solution of the more important problems of mortar firing is believed to be as accurate and as easy to use as any other that has been proposed. The tables are an extension of those first published in the Handbook.

The expression for the retardation for the Newtonian or quadratic law of resistance is

$$\frac{dv}{dt} = -\frac{A}{C}v^2,$$

in which v is the velocity of the projectile at any point of its flight, C the ballistic coefficient of the projectile and A a constant determined by experiment. The most satisfactory value of A (and the one used in computing these tables) is that deduced by General Mayevski from a discussion of the Krupp firings with projectiles having ogival heads struck with radii of two calibers.† For the units employed in our artillery service we have

$$\log A = 5.6698755 - 10.$$

These tables were constructed as follows (Handbook, page 292): First, for any assumed value of $\frac{V}{\sqrt{C}}$ and angle of elevation φ, compute the auxiliary angle i by the equation

$$(i) = (\varphi) + \frac{gC}{2AV^2\cos^2\varphi},$$

* For an exposition of this method, see Appendix II of the author's Handbook of Problems in Direct Fire. New York, 1890.

† See Exterior Ballistics in the Plane of Fire. New York, 1886. Page 29.

in which (i) and (φ) are functions of these angles whose values, extending from 0° to 87°, constitute Otto's Table I. Second, having found i enter Otto's Tables II and III with the arguments i and φ (called by Otto α and W respectively) and take out the quantities ξ, θ and ω (the latter being the angle of fall). Then we have the equations

$$\frac{X}{C} = \frac{M}{2A}\xi \quad . \quad \log\frac{M}{2A} = 4.39131,$$

$$\frac{T}{\sqrt{C}} = \frac{M}{\sqrt{2Ag}}\theta \quad . \quad \log\frac{M}{\sqrt{2Ag}} = 1.62293,$$

$$\frac{v_\omega}{\sqrt{C}} = \left(\frac{g}{2A}\right)^{\frac{1}{2}}\frac{\sec\omega}{\sqrt{(i)+(\omega)}} \quad . \quad \log\left(\frac{g}{2A}\right)^{\frac{1}{2}} = \bar{2}.76838,$$

in which X is the horizontal range, T the time of flight, ω the angle of fall, v_ω the striking velocity and M the reciprocal of the modulus of common logarithms. From these equations $\frac{X}{C}$, $\frac{T}{\sqrt{C}}$ and $\frac{v_\omega}{\sqrt{C}}$ are computed for each assumed value of φ and for equidistant values of $\frac{V}{\sqrt{C}}$, this latter constituting the argument of the tables.

There are eight tables here given corresponding to values of φ extending from 30° to 65° inclusive, with intervals of 5°. For each of these tables the argument $\frac{V}{\sqrt{C}}$ extends from 100 to 800 with a common difference of 10. These limits are sufficiently extensive for the solution of all practical problems of mortar firing. For problems relating to our heavy sea-coast mortars the upper half of the tables will be needed, while the lower portions will be required should it be desirable to employ our field and mountain guns temporarily as mortars. The method of using the tables is best shown by examples.

Example 1.—A 3-inch projectile weighing 9 lbs. was fired at an angle of departure of 45° and a M. V. of 720 f. s. What was the range, time of flight, angle of fall and striking velocity?

Omitting atmospheric conditions we have

$$C = \frac{w}{d^2} = \frac{9}{(3)^2} = 1.$$

We take, therefore, directly from the table, page 65,

$$X = 10479 \text{ ft.} = 3493 \text{ yards},$$

$$T = 27.84 \text{ seconds},$$
$$\omega = 55^\circ\ 16',$$
$$v_\omega = 495 \text{ f. s.}$$

This example illustrates the fact that these tables are simply range-tables for a projectile whose ballistic coefficient is unity.

Example 2.—A projectile whose ballistic coefficient is 4 was fired from a suitable mortar with an angle of elevation of 60°. The observed range was 6200 yards. What was the M. V., time of flight, angle of fall and striking velocity?

We have $\varphi = 60^\circ$, $X = 18600$ ft., and $\frac{X}{C} = 4650$. From the table on page 70 we find by an obvious interpolation,

$$\frac{V}{\sqrt{C}} = 460 + \frac{10 \times (4650 - 4563)}{159} = 455.5,$$

$$\frac{T}{\sqrt{C}} = 23.18 + \frac{0.44 \times 87}{159} = 23.42,$$

$$\omega = 64^\circ\ 18' + \frac{87 \times 9'}{159} = 64^\circ\ 23',$$

$$\frac{v_\omega}{\sqrt{C}} = 390 + \frac{87 \times 6}{159} = 393.3.$$

$$\therefore\ V = 2 \times 465.5 = 931 \text{ f. s.}$$
$$T = 2 \times 23.42 = 46.84 \text{ seconds.}$$
$$v_\omega = 2 \times 393.3 = 786.6 \text{ f. s.}$$

Example 3.—The Hotchkiss 2-pounder mountain gun has a ballistic coefficient $C = 0.7225$, and therefore $\sqrt{C} = 0.85$. Suppose that in an engagement with Indians it is found necessary to employ this gun as a mortar by sinking the trail into the ground until as shown by the quadrant the gun has an elevation of 60°. If the distance to the point to be shelled is 927 yards, what M. V. must be used and what is the time of flight?

We have

$$\frac{X}{C} = \frac{3 \times 927}{0.7225} = 3850.5,$$

$$\frac{V}{\sqrt{C}} = \frac{10 \times (3850.5 - 3779)}{155} + 410 = 414.6,$$

$$\frac{T}{\sqrt{C}} = \frac{71.5 \times 0.45}{155} + 20.92 = 21.13,$$

$$\therefore\ V = 0.85 \times 414.6 = 352.4 \text{ f. s.}$$
$$T = 0.85 \times 21.13 = 17.96 \text{ seconds.}$$

A complete range-table for this gun (employed as a mortar) might give for each angle of elevation and with ranges for argument, a column of muzzle velocities with corresponding charges, so as to show at a glance what charge would be required for any given range and angle of elevation. Or, if fixed ammunition were furnished the gun, it would be necessary to determine by interpolation, using second differences, the proper angle of elevation to attain the given range with the M. V. due to the charge.

Example 4.—The service 12-inch B.L. mortar fires a cast-iron shell weighing 800 lbs., having an ogival head struck with a radius of $1\frac{1}{2}$ calibers. With a M. V. of 1020 f. s., what would be the range, time of flight, angle of fall and striking velocity—(*a*) when elevated 45°; (*b*) when elevated 60°?

We will first compute the ballistic coefficient C, whose complete value, taking into account atmospheric conditions,* is

$$C = f\frac{\delta_1}{\delta}\frac{w}{c\,d^2},$$

in which f is a factor depending upon the mean altitude of the projectile which is assumed to be two-thirds of the maximum altitude. Having computed the maximum ordinate (y_0) the altitude factor may be taken from the table on page 88, Handbook. But it is generally less laborious to compute the altitude factor (or rather its logarithm, which is all that is needed) as follows: We have (Handbook, page 307)

$$\log(\log f) = \log\left(\tfrac{2}{3}y_0\right) - 4.80626$$
$$= \log y_0 - 4.98235.$$

In the parabolic theory the maximum ordinate is given by the equation

$$y_0 = \tfrac{1}{4}X\tan\varphi;$$

and therefore for a series of ranges under a constant angle of elevation, like the tables here given, the maximum ordinate *in vacuo* would be a constant multiple of the range, namely $\frac{1}{4}\tan\varphi$. But in air this multiplier is not constant and is greater in all cases than $\frac{1}{4}\tan\varphi$. We may, however, for most practical purposes, assume a mean constant multiplier of the range which will give y_0 with all required accuracy. These multipliers are given at the beginning of each table, and also the expressions for $\log(\log f)$ in terms of the range.

* **Handbook. Pages 83 and 307.**

(*a*) In our example we have $\varphi = 45°$, $c = \dfrac{10}{9}$, $w = 800$, $d = 12$, $\dfrac{\delta_1}{\delta} = 1$, For these data the provisional range table gives $X =$ 27117 feet.* The computation may be arranged as follows, designating the ballistic coefficient uncorrected for altitude by C':

$$\begin{array}{rl} \log w = & 2.90309 \\ a.\,c.\ \log c = & 9.95424 \\ a.\,c.\ \log d^2 = & 7.84164 \\ \hline \log C' = & 0.69897 \\ \log f = & 0.07625 \\ \hline \log C = & 0.77522 \end{array} \qquad \begin{array}{rl} \log X = & 4.43324 \\ \text{const.} = & 5.55099 \\ \hline \log (\log f) = & 8.88225 \end{array}$$

We next find

$$\frac{V}{\sqrt{C}} = 417.82,$$

and from the proper table, by interpolation,

$$\frac{X}{C} = 4551,$$

$$\frac{T}{\sqrt{C}} = 17.48,$$

$$\omega = 49°\ 28',$$

$$\frac{v_\omega}{\sqrt{C}} = 355.$$

Whence

$$X = 27123 \text{ feet.}$$
$$T = 42''.67.$$
$$v_\omega = 866.65 \text{ f. s.}$$

(*b*) $\varphi = 60$. For an elevation of 60° the provisional range-table gives $X = 23703$ feet. Whence proceeding as before we find

$$\log C = 0.84504.$$
$$X = 23825 \text{ feet.}$$
$$T = 52''.38.$$
$$\omega = 63°\ 14'.$$
$$v_\omega = 902.14 \text{ f. s.}$$

The time of flight is an important element in aiming a mortar at a movable object, as an enemy's ship; and the angle of fall and striking velocity are useful in determining what the effect of the shot will be on striking.

* Artillery Circular I, page 214.

Example 5.—Given for the Krupp 28-cm. mortar. $w = 215.5$ kg, $\varphi = 45°$, $V = 308$ m.s. $= 1010.51$ f.s., $c = 1$ and $\frac{\delta_1}{\delta} \doteq 1$. Compute X, T, ω and v_ω. Correct for altitude taking for X the mean of ten shots fired, which was 7810 m $= 25623.6$ ft.

The answers are $X = 25571$ ft, $T = 41''.76$, $\omega = 50° 25'$ and $v_\omega = 827$ f.s. The difference between the computed range and the mean observed range is about one-fifth of one per cent.

Various other problems in mortar-firing may be solved by means of these tables. Indeed if any three of the quantities C, V, X, T, φ, ω and v_ω be given the others may be determined with more or less facility.

BALLISTIC TABLE FOR MORTAR FIRING.

$\varphi = 30^\circ$. $Y_0 = 0.15\,X$. $\log(\log f) = \log X - 5.80626$.

$\frac{V}{\sqrt{C}}$	$\frac{X}{C}$	D.	$\frac{T}{\sqrt{C}}$	D.	ω	D.	$\frac{v_\omega}{\sqrt{C}}$	D.
100	269	54	3.12	31	30° 24′	2	99	10
110	323	60	3.43	30	30 26	2	109	9
120	383	65	3.73	30	30 28	2	118	10
130	448	70	4.03	30	30 30	2	128	9
140	518	74	4.33	30	30 32	3	137	9
150	592	80	4.63	31	30 35	3	146	10
160	672	85	4.94	31	30 38	4	156	9
170	757	89	5.25	30	30 42	4	165	9
180	846	94	5.55	30	30 46	4	174	9
190	940	99	5.85	30	30 50	4	183	9
200	1039	103	6.15	30	30 54	5	192	8
210	1142	106	6.45	30	30 59	5	200	9
220	1248	110	6.75	29	31 04	5	209	9
230	1358	114	7.04	30	31 09	6	218	8
240	1472	119	7.34	30	31 15	6	226	8
250	1591	123	7.64	30	31 21	6	234	8
260	1714	127	7.94	29	31 27	6	242	8
270	1841	131	8.23	30	31 33	7	250	8
280	1972	134	8.53	30	31 40	6	258	8
290	2106	137	8.83	30	31 46	7	266	8
300	2243	141	9.13	29	31 53	7	274	7
310	2384	144	9.42	29	32 00	7	281	8
320	2528	147	9.71	29	32 07	7	289	7
330	2675	149	10.00	29	32 14	8	296	7
340	2824	152	10.29	29	32 22	7	303	7
350	2976	156	10.58	29	32 29	8	310	7
360	3132	160	10.87	29	32 37	8	317	7
370	3292	162	11.16	28	32 45	8	324	6
380	3454	163	11.44	28	32 53	8	330	7
390	3617	165	11.72	28	33 01	8	337	6
400	3782	167	12.00	28	33 09	9	343	6
410	3949	170	12.28	28	33 18	9	349	6
420	4119	172	12.56	28	33 27	9	355	6
430	4291	175	12.84	27	33 36	9	361	6
440	4466	177	13.11	28	33 45	8	367	6
450	4643	178	13.39	27	33 53	9	373	5
460	4821	180	13.66	27	34 02	9	378	6
470	5001	181	13.93	27	34 11	10	384	5
480	5182	183	14.20	27	34 21	9	389	5
490	5365	184	14.47	27	34 30	9	394	5
500	5549	184	14.74	27	34 39	10	399	5
510	5733	185	15.01	26	34 49	10	404	5

$\varphi = 30°$—(continued.)

$\frac{V}{\sqrt{C}}$	$\frac{X}{C}$	D.	$\frac{T}{\sqrt{C}}$	D.	ω	D.	$\frac{v_\omega}{\sqrt{C}}$	D.
520	5918	187	15.27	26	34° 59′	10	409	5
530	6105	189	15.53	26	35 09	9	414	5
540	6294	189	15.79	26	35 18	10	419	5
550	6483	191	16.05	26	35 28	10	424	4
560	6674	192	16.31	26	35 38	10	428	4
570	6866	193	16.57	25	35 48	9	432	4
580	7059	192	16.82	25	35 57	10	436	5
590	7251	192	17.07	25	36 07	10	441	4
600	7443	193	17.32	25	36 17	10	445	4
610	7636	194	17.57	25	36 27	11	449	4
620	7830	194	17.82	25	36 38	10	453	4
630	8024	195	18.07	24	36 48	10	457	3
640	8219	195	18.31	25	36 58	10	460	4
650	8414	196	18.56	24	37 08	11	464	3
660	8610	197	18.80	24	37 19	10	467	4
670	8807	197	19.04	24	37 29	11	471	3
680	9004	196	19.28	24	37 40	10	474	4
690	9200	196	19.52	23	37 50	11	478	3
700	9396	196	19.75	23	38 01	11	481	3
710	9592	197	19.98	23	38 12	11	484	3
720	9789	197	20.21	23	38 23	10	487	3
730	9986	197	20.44	23	38 33	11	490	3
740	10183	196	20.67	23	38 44	10	493	3
750	10379	195	20.90	22	38 54	11	496	3
760	10574	196	21.12	23	39 05	11	499	3
770	10770	196	21.35	22	39 16	11	502	2
780	10966	195	21.57	23	39 27	11	504	3
790	11161	196	21.80	22	39 38	11	507	3
800	11357	196	22.02	22	39 49	11	510	3

BALLISTIC TABLE FOR MORTAR FIRING.

$\varphi = 35^\circ$. $Y_0 = 0.19\,X$. $\log(\log f) = \log X - 5.70360$.

$\frac{V}{\sqrt{C}}$	$\frac{X}{C}$	D.	$\frac{T}{\sqrt{C}}$	D.	ω	D.	$\frac{v_\omega}{\sqrt{C}}$	D.
100	291	61	3.58	35	35° 31′	2	99	10
110	352	65	3.93	35	35 33	2	109	9
120	417	70	4.28	35	35 35	2	118	10
130	487	75	4.63	34	35 37	2	128	9
140	562	81	4.97	35	35 39	3	137	10
150	643	86	5.32	35	35 42	3	147	9
160	729	90	5.67	35	35 45	3	156	9
170	819	96	6.02	34	35 48	4	165	9
180	915	101	6.36	35	35 52	4	174	9
190	1016	105	6.71	34	35 56	4	183	9
200	1121	110	7.05	35	36 00	4	192	9
210	1231	115	7.40	34	36 04	5	201	8
220	1346	119	7.74	34	36 09	5	209	9
230	1465	123	8.08	34	36 14	6	218	8
240	1588	127	8.42	34	36 20	7	226	8
250	1715	132	8.76	34	36 27	7	234	8
260	1847	136	9.10	34	36 34	8	242	8
270	1983	140	9.44	34	36 42	8	250	8
280	2123	145	9.78	34	36 50	9	258	8
290	2268	147	10.12	33	36 59	9	266	7
300	2415	148	10.45	33	37 08	9	273	8
310	2563	152	10.78	33	37 17	9	281	7
320	2715	158	11.11	33	37 26	9	288	7
330	2873	162	11.44	33	37 35	9	295	7
340	3035	163	11.77	33	37 44	9	302	7
350	3198	164	12.10	32	37 53	9	309	7
360	3362	166	12.42	33	38 02	9	316	7
370	3528	171	12.75	32	38 11	9	323	6
380	3699	174	13.07	32	38 20	9	329	7
390	3873	175	13.39	32	38 29	10	336	6
400	4048	177	13.71	32	38 39	10	342	6
410	4225	180	14.03	32	38 49	10	348	6
420	4405	182	14.35	31	38 59	10	354	6
430	4587	182	14.66	31	39 09	10	360	6
440	4769	185	14.97	31	39 19	10	366	6
450	4954	186	15.28	31	39 29	10	372	5
460	5140	188	15.59	30	39 39	10	377	6
470	5328	190	15.89	31	39 49	11	383	5
480	5518	192	16.20	30	40 00	11	388	5
490	5710	194	16.50	31	40 11	11	393	5
500	5904	194	16.81	30	40 22	11	398	5
510	6098	194	17.11	29	40 33	11	403	5

$\varphi = 35^\circ$—(continued).

$\frac{V}{\sqrt{C}}$	$\frac{X}{C}$	D.	$\frac{T}{\sqrt{C}}$	D.	ω	D.	$\frac{v_\omega}{\sqrt{C}}$	D.
520	6292	195	17.40	29	40° 44′	11	408	5
530	6487	196	17.69	29	40 55	11	413	4
540	6683	197	17.98	30	41 06	11	417	5
550	6880	198	18.28	29	41 17	11	422	4
560	7078	199	18.57	29	41 28	11	426	5
570	7277	200	18.86	29	41 39	12	431	4
580	7477	200	19.15	28	41 51	11	435	4
590	7677	201	19.43	28	42 02	12	439	4
600	7878	201	19.71	28	42 14	11	443	4
610	8079	201	19.99	28	42 25	12	447	4
620	8280	202	20.27	28	42 37	11	451	4
630	8482	201	20.55	27	42 48	12	455	4
640	8683	202	20.82	28	43 00	11	459	4
650	8885	201	21.10	27	43 11	11	463	3
660	9086	202	21.37	27	43 22	12	466	4
670	9288	201	21.64	26	43 34	11	470	3
680	9489	201	21.90	27	43 45	12	473	3
690	9690	201	22.17	26	43 57	11	476	3
700	9891	201	22.43	26	44 08	12	479	4
710	10092	200	22.69	26	44 20	11	483	3
720	10292	201	22.95	26	44 31	12	486	3
730	10493	200	23.21	25	44 43	11	489	3
740	10693	200	23.46	26	44 54	11	492	3
750	10893	200	23.72	25	44 05	11	495	3
760	11093	200	23.97	25	45 16	12	598	3
770	11293	199	24.22	25	45 28	11	501	3
780	11492	199	24.47	25	45 39	12	504	3
790	11691	198	24.72	24	45 51	11	507	2
800	11889	198	24.96	24	46 02	12	509	3

BALLISTIC TABLE FOR MORTAR FIRING.

$\varphi = 40^{\circ}$. $Y_0 = 0.23\ X$. $\log(\log f) = \log X - 5.62062$.

$\frac{V}{\sqrt{C}}$	$\frac{X}{C}$	D.	$\frac{T}{\sqrt{C}}$	D.	ω	D.	$\frac{v_\omega}{\sqrt{C}}$	D.
100	305	63	4.02	39	40° 28′	3	99	10
110	368	69	4.41	39	40 31	3	109	9
120	437	74	4.80	39	40 34	3	118	10
130	511	79	5.19	39	40 37	4	128	9
140	590	84	5.58	39	40 41	4	137	10
150	674	90	5.97	38	40 45	4	147	9
160	764	95	6.35	39	40 49	5	156	9
170	859	100	6.74	29	40 54	5	165	9
180	959	106	7.13	39	40 59	6	174	9
190	1065	110	7.52	38	41 05	6	183	9
200	1175	115	7.90	39	41 11	6	192	9
210	1290	120	8.29	38	41 17	6	201	8
220	1410	124	8.67	38	41 23	6	209	9
230	1534	128	9.05	38	41 29	7	218	8
240	1662	133	9.43	38	41 36	7	226	8
250	1795	137	9.81	38	41 43	8	234	8
260	1932	140	10.19	38	41 51	8	242	8
270	2072	144	10.57	37	41 59	8	250	8
280	2216	147	10.94	38	42 07	8	258	8
290	2363	151	11.32	37	42 15	8	266	7
300	2514	155	11.69	37	42 23	9	273	7
310	2669	158	12.06	37	42 32	9	280	8
320	2827	161	12.43	37	42 41	9	288	7
330	2988	165	12.80	36	42 50	10	295	7
340	3153	168	13.16	36	43 00	9	302	7
350	3321	171	13.52	36	43 09	10	309	7
360	3492	174	13.88	36	43 19	10	316	6
370	3666	175	14.24	36	43 29	11	322	7
380	3841	177	14.60	36	43 40	10	329	6
390	4018	180	14.96	35	43 50	10	335	7
400	4198	183	15.31	36	44 00	10	342	6
410	4381	186	15.67	35	44 10	11	348	6
420	4567	186	16.02	34	44 21	11	354	6
430	4753	187	16.36	35	44 32	11	360	6
440	4940	188	16.71	34	44 43	11	366	6
450	5128	190	17.05	35	44 54	11	372	6
460	5318	193	17.40	34	45 05	11	378	5
470	5511	194	17.74	33	45 16	11	383	5
480	5705	194	18.07	33	45 27	11	388	6
490	5899	195	18.40	33	45 38	12	394	5
500	6094	197	18.73	33	45 50	11	399	5
510	6291	197	19.06	33	46 01	12	404	5

$\varphi = 40^\circ$—(Continued.)

$\frac{V}{\sqrt{C}}$	$\frac{X}{C}$	D.	$\frac{T}{\sqrt{C}}$	D.	ω	D.	$\frac{v_\omega}{\sqrt{C}}$	D.
520	6488	199	19.39	33	46° 13′	11	409	5
530	6687	199	19.72	32	46 24	12	414	4
540	6886	201	20.04	32	46 36	12	418	5
550	7087	201	20.36	32	46 48	12	423	4
560	7288	201	20.68	32	47 00	12	427	5
570	7489	201	21.00	31	47 12	12	432	4
580	7690	201	21.31	32	47 24	12	436	5
590	7891	201	21.63	31	47 36	11	441	4
600	8092	202	21.94	31	47 47	12	445	4
610	8294	203	22.25	31	47 59	12	449	4
620	8497	203	22.56	30	48 11	12	453	4
630	8700	203	22.86	30	48 23	12	457	4
640	8903	203	23.16	30	48 35	12	461	4
650	9106	203	23.46	30	48 47	12	465	3
660	9309	204	23.76	30	48 59	12	468	4
670	9513	204	24.06	29	49 11	12	472	4
680	9717	202	24.35	29	49 23	12	476	4
690	9919	201	24.64	29	49 35	11	480	3
700	10120	201	24.93	29	49 46	12	483	4
710	10321	200	25.22	28	49 58	11	487	3
720	10521	201	25.50	29	50 09	12	490	3
730	10722	200	25.79	28	50 21	11	493	3
740	10922	199	26.07	28	50 32	12	496	3
750	11121	199	26.35	27	50 44	11	499	3
760	11320	198	26.62	27	50 55	12	502	3
770	11518	198	26.89	27	51 07	11	505	3
780	11716	197	27.16	27	51 18	12	508	3
790	11913	197	27.43	26	51 30	11	511	3
800	12110	196	27.69	26	51 41	11	514	3

BALLISTIC TABLE FOR MORTAR FIRING.

$\varphi = 45^{\circ}$ $Y_0 = 0.27\,X$. $\log(\log f) = \log X - 5.55099$.

$\frac{V}{\sqrt{C}}$	$\frac{X}{C}$	D.	$\frac{T}{\sqrt{C}}$	D.	ω	D.	$\frac{v_\omega}{\sqrt{C}}$	D.
100	308	64	4.39	44	45° 27′	2	100	10
110	372	69	4.83	44	45 29	3	110	9
120	441	75	5.27	43	45 32	3	119	9
130	516	80	5.70	43	45 35	3	128	9
140	596	86	6.13	43	45 38	4	137	9
150	682	91	6.56	42	45 42	5	146	10
160	773	96	6.98	43	45 47	5	156	9
170	869	101	7.41	42	45 52	6	165	9
180	970	106	7.83	43	45 58	6	174	9
190	1076	111	8.26	42	46 04	7	183	9
200	1187	116	8.68	43	46 11	7	192	9
210	1303	120	9.11	42	46 18	7	201	8
220	1423	125	9.53	42	46 25	7	209	8
230	1548	129	9.95	42	46 32	8	217	9
240	1677	134	10.37	41	46 40	8	226	8
250	1811	139	10.78	41	46 48	7	234	8
260	1950	142	11.19	42	46 55	8	242	8
270	2092	146	11.61	41	47 03	8	250	8
280	2238	150	12.02	41	47 11	8	258	8
290	2388	153	12.43	40	47 19	9	266	7
300	2541	157	12.83	41	47 28	9	273	8
310	2698	160	13.24	40	47 37	9	281	7
320	2858	162	13.64	41	47 46	10	288	8
330	3020	165	14.05	40	47 56	10	296	7
340	3185	167	14.45	39	48 06	10	303	7
350	3352	169	14.84	40	48 16	10	310	7
360	3521	172	15.24	39	48 26	10	317	7
370	3693	175	15.63	39	48 36	11	324	6
380	3868	177	16.02	39	48 47	10	330	7
390	4045	180	16.41	38	48 57	11	337	6
400	4225	182	16.79	39	49 08	11	343	7
410	4407	184	17.18	38	49 19	11	350	6
420	4591	185	17.56	38	49 30	11	356	6
430	4776	187	17.94	38	49 41	11	362	6
440	4963	188	18.32	37	49 52	11	368	6
450	5151	190	18.69	37	50 03	11	374	5
460	5341	192	19.06	37	50 14	11	379	6
470	5533	194	19.43	36	50 25	12	385	5
480	5727	194	19.79	37	50 37	11	390	6
490	5921	195	20.16	36	50 48	12	396	5
500	6116	197	20.52	36	51 00	12	401	5
510	6313	197	20.88	36	51 12	12	406	5

$\varphi = 45^\circ$—(continued.)

$\frac{V}{\sqrt{C}}$	$\frac{X}{C}$	D.	$\frac{T}{\sqrt{C}}$	D.	ω	D.	$\frac{v_\omega}{\sqrt{C}}$	D.
520	6510	197	21.24	35	51° 24′	11	411	5
530	6707	197	21.59	35	51 35	12	416	5
540	6904	198	21.94	35	51 47	11	421	5
550	7102	198	22.29	35	51 58	12	426	5
560	7300	198	22.64	34	52 10	12	431	5
570	7498	199	22.98	34	52 22	12	436	4
580	7697	199	23.32	34	52 34	11	440	5
590	7896	199	23.66	34	52 45	12	445	4
600	8095	199	24.00	34	52 57	12	449	4
610	8294	200	24.34	33	53 09	12	453	4
620	8494	200	24.67	33	53 21	12	457	4
630	8694	199	25.00	32	53 33	11	461	4
640	8893	200	25.32	33	53 44	12	465	4
650	9093	199	25.65	32	53 56	11	469	4
660	9292	199	25.97	32	54 07	12	473	4
670	9491	198	26.29	31	54 19	11	477	4
680	9689	198	26.60	32	54 30	12	481	4
690	9887	198	26.92	31	54 42	11	485	3
700	10085	197	27.23	31	54 53	12	488	4
710	10282	197	27.54	30	55 05	11	492	3
720	10479	196	27.84	31	55 16	11	495	4
730	10675	195	28.15	30	55 27	11	499	3
740	10870	195	28.45	30	55 38	12	502	4
750	11065	194	28.75	29	55 50	11	506	3
760	11259	194	29.04	30	56 01	11	509	2
770	11453	193	29.34	29	56 12	11	512	3
780	11646	193	29.63	30	56 23	11	515	3
790	11839	193	29.93	29	56 34	11	518	3
800	12032	192	30.22	29	56 45	11	521	3

BALLISTIC TABLE FOR MORTAR FIRING.

$\varphi = 50^\circ$. $Y_0 = 0.32\ X$. $\log(\log f) = \log X - 5.47720$.

$\frac{V}{\sqrt{C}}$	$\frac{X}{C}$	D.	$\frac{T}{\sqrt{C}}$	D.	ω	D.	$\frac{v_\omega}{\sqrt{C}}$	D.
100	302	64	4.76	47	50° 30′	3	99	10
110	366	79	5.23	47	50 33	3	109	10
120	435	74	5.70	47	50 36	3	119	9
130	509	79	6.17	47	50 39	4	128	9
140	588	85	6.64	46	50 43	4	137	10
150	673	89	7.10	46	50 47	5	147	9
160	762	95	7.56	47	50 52	4	156	9
170	857	99	8.03	46	50 56	5	165	9
180	956	104	8.49	46	51 01	5	174	9
190	1060	109	8.95	45	51 06	5	183	9
200	1169	114	9.40	46	51 11	6	192	9
210	1283	119	9.86	45	51 17	6	201	8
220	1402	124	10.31	45	51 23	7	209	9
230	1526	128	10.76	45	51 30	8	218	8
240	1654	131	11.21	45	51 38	8	226	9
250	1785	135	11.66	45	51 46	8	235	8
260	1920	139	12.11	45	51 54	8	243	8
270	2059	143	12.56	45	52 02	9	251	8
280	2202	146	13.01	44	52 11	8	259	8
290	2348	148	13.45	44	52 19	9	267	8
300	2496	152	13.89	43	52 28	9	275	8
310	2648	154	14.32	43	52 37	9	283	7
320	2802	157	14.75	43	52 46	9	290	7
330	2959	161	15.18	43	52 55	10	297	7
340	3120	164	15.61	43	53 05	9	304	7
350	3284	166	16.04	43	53 14	10	311	7
360	3450	167	16.47	43	53 24	9	318	7
370	3617	170	16.90	42	53 33	10	325	7
380	3787	173	17.32	41	53 43	10	332	7
390	3960	176	17.73	41	53 53	11	339	6
400	4136	178	18.14	41	54 04	11	345	7
410	4314	178	18.55	41	54 15	11	352	6
420	4492	179	18.96	41	54 26	10	358	7
430	4671	181	19.37	41	54 36	11	365	6
440	4852	183	19.78	40	54 47	10	371	6
450	5035	185	20.18	40	54 57	11	377	6
460	5220	186	20.58	40	55 08	11	383	6
470	5406	186	20.98	39	55 19	11	389	5
480	5592	188	21.37	39	55 30	11	394	6
490	5780	189	21.76	39	55 41	12	400	5
500	5969	190	22.15	39	55 53	11	405	6
510	6159	191	22.54	38	56 04	11	411	5

$\varphi = 50°$—(continued.)

$\frac{V}{\sqrt{C}}$	$\frac{X}{C}$	D.	$\frac{T}{\sqrt{C}}$	D.	ω	D.	$\frac{v_\omega}{\sqrt{C}}$	D.
520	6350	192	22.92	38	56° 15′	11	416	5
530	6542	192	23.30	38	56 26	11	421	5
540	6734	192	23.68	38	56 37	12	426	5
550	6926	192	24.06	37	56 49	11	431	5
560	7118	192	24.43	37	57 00	11	436	5
570	7310	192	24.80	36	57 11	11	441	4
580	7502	192	25.16	36	57 22	11	445	5
590	7694	192	25.52	36	57 33	11	450	4
600	7886	192	25.88	36	57 44	12	454	5
610	8078	193	26.24	36	57 56	11	459	4
620	8271	192	26.60	35	58 07	11	463	5
630	8463	191	26.95	35	58 18	11	468	4
640	8654	192	27.30	35	58 29	11	472	4
650	8846	191	27.65	34	58 40	11	476	4
660	9037	191	27.99	34	58 51	11	480	4
670	9228	191	28.33	34	59 02	11	484	4
680	9419	190	28.67	33	59 13	11	488	4
690	9609	190	29.00	33	59 24	10	492	4
700	9799	190	29.33	33	59 34	11	496	4
710	9989	189	29.66	32	59 45	10	500	3
720	10178	188	29.98	33	59 55	11	503	4
730	10366	188	30.31	33	60 06	10	507	3
740	10554	188	30.64	33	60 16	11	510	4
750	10742	187	30.97	32	60 27	10	514	3
760	10929	186	31.29	32	60 37	11	517	3
770	11115	185	31.61	31	60 48	10	520	3
780	11300	185	31.92	30	60 58	11	523	4
790	11485	184	32.22	30	61 09	10	527	3
800	11669	183	32.52	29	61 19	11	530	3

BALLISTIC TABLE FOR MORTAR FIRING.

$\varphi = 55°$. $Y_0 = 0.38\,X$. $\log(\log f) = \log X - 5.40257$.

$\frac{V}{\sqrt{C}}$	$\frac{X}{C}$	D.	$\frac{T}{\sqrt{C}}$	D.	ω	D.	$\frac{v'_\omega}{\sqrt{C}}$	D.
100	289	60	5.08	51	55° 23'	4	99	10
110	349	66	5.59	50	55 27	4	109	10
120	415	71	6.09	50	55 31	4	119	9
130	486	76	6.59	50	55 35	5	128	9
140	562	81	7.09	50	55 40	4	137	10
150	643	85	7.59	49	55 44	4	147	9
160	728	90	8.08	50	55 48	5	156	9
170	818	94	8.58	49	55 53	5	165	9
180	912	99	9.07	49	55 58	5	174	9
190	1011	103	9.56	49	56 03	5	183	9
200	1114	108	10.05	49	56 08	6	192	9
210	1222	113	10.54	48	56 14	6	201	9
220	1335	117	11.02	49	56 20	6	210	9
230	1452	121	11.51	48	56 26	7	219	8
240	1573	125	11.99	48	56 33	7	227	9
250	1698	129	12.47	48	56 40	8	236	8
260	1827	132	12.95	48	56 48	8	244	8
270	1959	136	13.43	47	56 56	8	252	8
280	2095	139	13.90	47	57 04	8	260	9
290	2234	142	14.37	47	57 12	9	269	8
300	2376	145	14.84	47	57 21	8	277	8
310	2521	147	15.31	46	57 29	9	285	7
320	2668	150	15.77	46	57 38	8	292	8
330	2818	153	16.23	45	57 46	9	300	7
240	2971	156	16.68	46	57 55	9	307	7
350	3127	158	17.14	45	58 04	9	314	7
360	3285	160	17.59	45	58 13	9	321	7
370	3445	162	18.04	44	58 22	9	328	7
380	3607	163	18.48	45	58 31	9	335	7
390	3770	165	18.93	44	58 40	10	342	6
400	3935	167	19.37	44	58 50	9	348	7
410	4102	170	19.81	44	58 59	10	355	6
420	4272	170	20.25	43	59 09	10	361	7
430	4442	170	20.68	43	59 19	10	368	6
440	4612	172	21.11	42	59 29	10	374	6
450	4784	175	21.53	43	59 39	10	380	6
460	4959	176	21.96	42	59 49	10	386	6
470	5135	176	22.38	42	59 59	11	392	6
480	5311	177	22.80	42	60 10	10	398	6
490	5488	179	23.22	41	60 20	11	404	6
500	5667	180	23.63	41	60 31	10	410	6
510	5847	181	24.04	41	60 41	10	416	5

$\varphi = 55^\circ$—(continued.)

$\frac{V}{\sqrt{C}}$	$\frac{X}{C}$	D.	$\frac{T}{\sqrt{C}}$	D.	ω	D.	$\frac{v_\omega}{\sqrt{C}}$	D.
520	6028	180	24.45	40	60° 51′	11	421	5
530	6208	181	24.85	40	61 02	10	426	5
540	6389	180	25.25	40	61 12	10	431	5
550	6569	181	25.65	39	61 22	10	436	5
560	6750	181	26.04	39	61 32	10	441	5
570	6931	181	26.43	39	61 42	10	446	5
580	7112	181	26.82	38	61 52	10	451	5
590	7293	182	27.20	38	62 02	10	456	4
600	7475	181	27.58	38	62 12	11	460	5
610	7656	182	27.96	37	62 23	10	465	5
620	7838	181	28.33	37	62 33	10	470	5
630	8019	181	28.70	37	62 43	10	475	4
640	8200	180	29.07	37	62 53	10	479	4
650	8380	180	29.44	36	63 03	9	483	4
660	8560	180	29.80	36	63 12	10	487	5
670	8740	179	30.16	36	63 22	10	492	4
680	8919	179	30.52	36	63 32	10	496	4
690	9098	179	30.88	35	63 42	9	500	4
700	9277	178	31.23	35	63 51	10	504	4
710	9455	177	31.58	35	64 01	10	508	4
720	9632	177	31.93	34	64 11	10	512	4
730	9809	176	32.27	34	64 21	9	516	3
740	9985	175	32.61	34	64 30	10	519	3
750	10160	175	32.95	34	64 40	9	522	4
760	10335	173	33.29	33	64 49	10	526	3
770	10508	173	33.62	33	64 59	9	529	3
780	10681	172	33.95	33	65 08	10	532	4
790	10853	172	34.28	32	65 18	9	536	3
800	11025	171	34.60	32	65 27	9	539	3

BALLISTIC TABLE FOR MORTAR FIRING.

$\varphi = 60^\circ$. $Y_0 = 0.47\ X$. $\log(\log f) = \log X - 5.31025$.

$\frac{V}{\sqrt{C}}$	$\frac{X}{C}$	*D.*	$\frac{T}{\sqrt{C}}$	*D.*	ω	*D.*	$\frac{v_\omega}{\sqrt{C}}$	*D.*
100	265	56	5.37	53	60° 19′	4	99	10
110	321	60	5.90	53	60 23	4	109	10
120	381	65	6.43	53	60 27	4	119	10
130	446	70	6.96	53	60 31	4	129	9
140	516	74	7.49	53	60 35	4	138	10
150	590	79	8.02	52	60 39	4	148	9
160	669	83	8.54	52	60 43	4	157	9
170	752	87	9.06	52	60 47	5	166	9
180	839	92	9.58	52	60 52	5	175	9
190	931	97	10.10	52	60 57	5	184	9
200	1028	100	10.62	52	61 02	5	193	9
210	1128	103	11.14	51	61 07	6	202	9
220	1231	107	11.65	51	61 13	6	211	9
230	1338	111	12.16	51	61 19	6	220	8
240	1449	115	12.67	51	61 25	6	228	9
250	1564	118	13.18	50	61 31	7	237	8
260	1682	122	13.68	50	61 38	6	245	8
270	1804	125	14.18	50	61 44	7	253	8
280	1929	128	14.68	50	61 51	7	261	8
290	2057	131	15.18	49	61 58	7	269	8
300	2188	133	15.67	49	62 05	8	277	8
310	2321	136	16.16	49	62 13	7	285	8
320	2457	138	16.65	49	62 20	8	293	8
330	2595	140	17.14	49	62 28	8	301	7
340	2735	143	17.63	48	62 36	8	308	8
350	2878	145	18.11	48	62 44	8	316	7
360	3023	148	18.59	48	62 52	9	323	7
370	3171	149	19.07	47	63 01	8	330	7
380	3320	152	19.54	46	63 09	9	337	7
390	3472	153	20.00	46	63 18	8	344	7
400	3625	154	20.46	46	63 26	9	351	7
410	3779	155	20.92	45	63 35	8	358	6
420	3934	156	21.37	46	63 43	9	364	7
430	4090	157	21.83	46	63 52	8	371	6
440	4247	158	22.29	45	64 00	9	377	7
450	4405	158	22.74	44	64 09	9	384	6
460	4563	159	23.18	44	64 18	9	390	6
470	4722	162	23.62	44	64 27	9	396	6
480	4884	163	24.06	44	64 36	9	402	6
490	5047	164	24.50	43	64 45	9	408	6
500	5211	165	24.93	43	64 54	9	414	6
510	5376	165	25.36	43	65 03	9	420	5

$\varphi = 60^{\circ}$—(continued).

$\frac{V}{\sqrt{C}}$	$\frac{X}{C}$	D.	$\frac{T}{\sqrt{C}}$	D.	ω	D.	$\frac{v_{\omega}}{\sqrt{C}}$	D.
520	5541	165	25.79	42	65° 12′	9	425	6
530	5706	166	26.21	42	65 21	9	431	5
540	5872	166	26.63	42	65 30	9	436	6
550	6038	167	27.05	41	65 39	9	442	5
560	6205	167	27.46	41	65 48	9	447	5
570	6372	168	27.87	41	65 57	10	452	5
580	6540	167	28.28	41	66 07	9	457	5
590	6707	168	28.69	40	66 16	9	462	5
600	6875	167	29.09	40	66 25	9	467	5
610	7042	167	29.49	40	66 34	9	472	5
620	7209	167	29.89	40	66 43	9	477	5
630	7376	166	30.29	39	66 52	9	482	4
640	7542	166	30.68	39	67 01	9	486	5
650	7708	165	31.07	38	67 10	9	491	4
660	7873	164	31.45	39	67 19	9	495	5
670	8037	164	31.84	38	67 28	9	500	4
680	8201	164	32.22	38	67 37	9	504	4
690	8365	163	32.60	37	67 46	8	508	4
700	8528	163	32.97	37	67 54	9	512	4
710	8691	162	33.34	36	68 03	8	516	4
720	8853	160	33.70	36	68 11	9	520	4
730	9013	160	34.06	35	68 20	8	524	3
740	9173	159	34.41	35	68 28	8	527	4
750	9332	158	34.76	35	68 36	8	531	4
760	9490	157	35.11	34	68 44	8	535	4
770	9647	157	35.45	34	68 52	8	539	3
780	9804	156	35.79	33	69 00	8	542	3
790	9960	155	36.12	33	69 08	7	545	3
800	10115	154	36.45	32	69 15	7	548	3

BALLISTIC TABLE FOR MORTAR FIRING.

$\varphi = 65°$. $V_\omega = 0.60\,X$. $\log(\log f) = \log X - 5.204320$.

$\frac{V}{\sqrt{C}}$	$\frac{X}{C}$	D.	$\frac{T}{\sqrt{C}}$	D.	ω	D.	$\frac{v_\omega}{\sqrt{C}}$	D.
100	234	49	5.61	56	65° 12′	4	99	10
110	283	53	6.17	56	65 16	4	109	10
120	336	58	6.73	56	65 20	4	119	10
130	394	61	7.29	55	65 24	4	129	9
140	455	64	7.84	56	65 28	4	138	10
150	519	69	8.40	55	65 32	4	148	9
160	588	74	8.95	55	65 36	4	157	10
170	662	78	9.50	54	65 40	4	167	9
180	740	82	10.04	54	65 44	4	176	9
190	822	86	10.58	54	65 48	5	185	9
200	908	89	11.12	54	65 53	4	194	9
210	997	92	11.66	54	65 57	5	203	9
220	1089	95	12.20	53	66 02	5	212	9
230	1184	98	12.73	53	66 07	5	221	8
240	1282	102	13.26	53	66 12	5	229	9
250	1384	106	13.79	53	66 17	6	238	8
260	1490	108	14.32	52	66 23	6	246	9
270	1598	110	14.84	52	66 29	6	255	8
280	1708	112	15.36	52	66 35	6	263	8
290	1820	115	15.88	51	66 41	6	271	8
300	1934	118	16.39	52	66 47	6	279	8
310	2052	120	16.91	51	66 53	6	287	8
320	2172	123	17.42	51	66 59	7	295	8
330	2295	125	17.93	50	67 06	7	303	7
340	2420	127	18.43	50	67 13	7	310	8
350	2547	128	18.93	50	67 20	7	318	7
360	2675	130	19.43	50	67 27	7	325	8
370	2805	132	19.93	49	67 34	7	333	7
380	2937	134	20.42	49	67 41	7	340	7
390	3071	135	20.91	48	67 48	7	347	7
400	3206	136	21.39	48	67 55	7	354	7
410	3342	137	21.87	48	68 02	7	361	7
420	3479	139	22.35	47	68 09	7	368	7
430	3618	141	22.82	47	68 16	8	375	6
440	3759	142	23.29	47	68 24	8	381	7
450	3901	143	23.76	47	68 32	7	388	6
460	4044	143	24.23	46	68 39	8	394	6
470	4187	144	24.69	46	68 47	7	400	6
480	4331	144	25.15	46	68 54	8	406	6
490	4475	144	25.61	45	69 02	8	412	6
500	4619	145	26.06	45	69 10	8	418	6
510	4764	146	26.51	45	69 18	7	424	6

$\varphi = 65^{\circ}$—(continued).

$\frac{V}{\sqrt{C}}$	$\frac{X}{C}$	D.	$\frac{T}{\sqrt{C}}$	D.	ω	D.	$\frac{v_{\omega}}{\sqrt{C}}$	D.
520	4910	146	26.96	44	69° 25′	8	430	6
530	5056	146	27.40	44	69 33	7	436	5
540	5202	146	27.84	43	69 40	8	441	6
550	5348	147	28.27	43	69 48	7	447	5
560	5495	146	28.70	43	69 55	8	452	6
570	5641	146	29.13	42	70 03	7	458	5
580	5787	146	29.55	42	70 10	8	463	5
590	5933	146	29.97	42	70 18	7	468	5
600	6079	146	30.39	41	70 25	7	473	5
610	6225	146	30.80	41	70 32	7	478	5
620	6371	146	31.21	41	70 39	8	483	5
630	6517	146	31.62	40	70 47	7	488	4
640	6663	145	32.02	40	70 54	8	492	5
650	6808	145	32.42	40	71 02	7	497	4
660	6953	145	32.82	40	71 09	7	501	5
670	7098	145	33.22	39	71 16	7	506	4
680	7243	145	33.61	39	71 23	7	510	4
690	7388	145	34.00	38	71 30	7	514	4
700	7533	144	34.38	38	71 37	7	518	4
710	7677	143	34.76	37	71 44	8	522	4
720	7820	144	35.13	38	71 52	7	526	4
730	7964	143	35.51	37	71 59	7	530	4
740	8107	142	35.88	37	72 06	7	534	4
750	8249	141	36.25	36	72 13	7	538	4
760	8390	141	36.61	37	72 20	8	542	4
770	8531	141	36.98	36	72 28	7	546	4
780	8672	140	37.34	36	72 35	7	550	4
790	8812	138	37.70	35	72 42	7	554	3
800	8950	137	38.05	35	72 49	7	557	4

A FEW HINTS ON MARCHING AT HOME AND ABROAD.

By Major J. HOTHAM, R. H. A.

Reprinted from the *Proceedings of the Royal Artillery Institution*, Woolwich, December, 1895.*

INTRODUCTION.

Nearly all officers have marched during their service and know all about it, but some there are probably who have passed most of their service abroad, and others who have served mostly at home; therefore as one who has had a great experience of marching in both countries, I have compiled these few notes with the hope that they may prove of assistance in some cases.

It is perhaps scarcely necessary to insist upon the importance of having the horses fit to march, before going on the road, hard and full of muscle, or to say that the harness should be soft and pliable, not harsh and brittle with beeswax and heelball, that the saddles should be in good order and not restuffed and pricked up some three or four days before starting (a certain cause of sore backs): that the valises should be well curved over the backs and should not be flat, and that the arches of the saddles should be well fitted to the withers of the horses. Still I have seen batteries at the end of a march arrive tied up in a sheep skin and numnah, the horses covered with galls, and looking like towel horses; I have seen cavalry with scores of sore backs, and these things I imagine must have come about owing to the C. O. having started unprepared and with flat, soft horses.

If horses start well on a march, and are treated judiciously for the first few days as regards the rate of travelling and halts they will arrive at the end in the best of condition, hard and bright, with no loose flesh but all muscle; provided of course the forage be fairly good and the weather ditto.

The officers should look over all saddles and harness carefully before starting, and see that everything fits, that all ties are made up and in good order, all the carriages in good repair, the horses shod up to date, and also that the store shoes are complete.

* We wish to express our regret that, in our last number, we omitted to give due credit to these *Proceedings* for our reprint of the Silver Prize Essay for 1895 by Major Nicolls.

They should lay down distinctly what kit is to be carried in the valises, etc. on the road, and what is to be packed in bags or left behind. They must insist on the kits being properly packed in the valises and blankets daily; I once opened a bulging valise on the Limerick and Tarbert road when starting on a 43 mile march, and found four pounds of bacon in the center, a nice lump on a horse's backbone! The officers must also see that kits if left behind are properly packed and stowed away in a safe store; the engineers may strip the roofs off your barracks while you are away, without letting you know, or without asking you to hand over, and the rain may come in and ruin the kits if left there. It has happened to me, and by some extraordinary reasoning I was ordered to make good half the damage, though I had left sentries and watchmen over the barracks, and had received no orders to hand over and vacate.

In India the officers should see to the details of carriage for tents and baggage, mess traps and cooking utensils (this is often neglected).

The farrier must look well to his shoeing, no long toes on rough and stony roads; a broken knee on the march is a very bad case. He must fit and pack his store shoes, no time on the march for such fitting, he should fill his field companion with dressings and physic, and also the regimental or battery chests. The government supply is but a poor one and none too liberal, so he had better ask the commanding officer to buy a few simple things, such as carbonate of ammonia, ginger, iodoform, nitric ether, laudanum, camphorated carbolic oil, epsom salts and some extra bandages and medicated lint. He must see to his needles and suture wires, weights and scales, and thermometer. He should also make up a few balls, two drachms carbonate ammonia, three drachms ginger and put them in a tin box, and mix a bottle of simple dressing for each shoeing-smith's satchel. Also he had better have two or three hinged shoes ready for the shoeing-smiths to tack on the road if necessary.

The collar maker should make up a few small pads with ties, and a set or two of skeleton harness in case of galls. Links and traces will sometimes rub from horses pulling unevenly; a few little shields of leather, and a few bits of sheep skin with ties should be made up so as to be able to pop them on quickly on the road; he should make up a dozen or so "dealers" or "Yorkshire boots;" horses will brush at times however well shod, and the soft cloth boot is far superior to the nasty hard leather things with straps that collar-makers delight in making.

What is wanted is merely a square or rectangular piece of old horse clothing, with a tie in the center to fasten round the leg, the top half folded down over the tie.

The sergeant major should see a box packed up with all writing materials and forms that he is likely to require on the road, the pay sergeant and the quartermaster sergeant, if the latter is marching, should do the same. In England the quartermaster sergeant will not be on the road, but in India he marches with the regiment or battery, or rather a day ahead carrying his office with him.

MARCHING AT HOME.

Orders are sure to be received with the route some days before the start, and it is well for the commanding officer to ask the firm with whom the regiment or battery bank to write to their agents at the different towns along the road to honor drafts. The captain, quartermaster sergeant and some few old married men will be left behind to close the barracks, send off the heavy baggage and kits, and to hand over to the barrack department; they will then, if the regiment or battery is making a permanent move, proceed by train to their destination; but if the vacation of barracks is only temporary, a senior non-commissioned officer and one or two trustworthy men, such as the storeman, will be left to take care of the barracks and stores during their absence.

The billeting party, which for a battery or squadron consists generally of two non-commissioned officers and two privates to look after their horses, will precede the battery or squadron by one day. The non-commissioned officers (and especially the senior) should be very intelligent, reliable men, with tact and good manners; for the comfort of the men depends a great deal on these doing their work in a satisfactory manner. The route or a copy of it will be in their charge, and on arriving at the town or village where the halt is to be made for the day, they should proceed and report their arrival to the superintendent of police showing the route; he will then issue the billets for themselves and their horses for that night, and later will give them in detail the billets for the regiment or battery. They should go round with a policeman and visit all billets and apportion them off, taking care as much as possible to keep the different units together.

The parade ground or gun-park is generally in the market place, and they should rent a room close by for a guard-room. The sergeant-major, farrier, senior trumpeter, and pay-sergeant should be billeted close to headquarters.

The billeting party should then draw up lists of the different houses, with the names of the streets where the billets are situated, for the use of the commanding officer, the pay sergeant, the sergeant major, and also for the subalterns and sergeants for their special commands.

It is advisable also for the senior non-commissioned officer to draw a rough sketch of the village or small town, filling in the names of the streets, headquarters, post office, station, and so on for the convenience of the commanding officer. This of course is impracticable in large towns. (We had a German bombardier in "C" troop in 1879 who had served in the Prussian army; he spoke broken English but his maps were wonderful. This man was promoted from "C" to "A" troop in 1880 and deserted very soon after; he had a clean defaulter sheet, and had risen to sergeant in about three years.)

The billeting party meet the regiment or battery when it arrives just outside the town and shows the commanding officer the way to the parade ground or gun-park, where they will distribute the lists and billets and give any directions they can to guide the men. This being done the party should get ready to go on to the next halt on receipt of orders from the commanding officer; it saves a deal of work to send the billeting party on by rail if possible; it gives them more time and they get through their work easier; I invariably did so myself, and it costs but little.

It is a good plan to pay the men daily at the mid-day halt, one day, say, one shilling, the next day eighteenpence, thus avoiding very small change. My own plan was as follows: this daily pay was put by the pay sergeant and myself overnight into six little bags, two of which I gave at breakfast the next morning to each subaltern, I kept a double set of bags and the empty ones were returned to me on my issuing the full ones; the bags were marked with the sub-division numbers.

I carried as a rule money enough for one day or two, but it depended of course on our vicinity to a bank. In some places there might be no bank at all.

I gave the pay sergeant daily the billeting money, and calculated out the pay, and entered it both in his pay-book and in my pocket-book; the pay sergeant should accompany the commanding officer round billets in the evening, and pay all up in the presence of the different sectional officers, taking receipts, which he should file—I had a book for him. Never but once in my experience of several long marches, have I had a demand for

repayment from an innkeeper, for the reason perhaps that an officer was always present to witness the payments. I also recommend that a copy of all payments be kept by the commanding officer personally. Pay-books may get lost, therefore a duplicate is useful; I had at one time a pay sergeant who was a capital fellow but inclined at times to go on the spree; he did so on the march once, and lost his books, and if I had not had a copy I should have been in a fix.

About 8:15 or 8:30 a. m. is the best time to get away on the road, it is not easily managed earlier, for the hotels and public-houses are not open much before 6:30 or 7 a. m., neither is it good for man or beast to make too early a start, unless the weather is abnormally hot. I remember once trying to start out of Bath at 6:30 a. m. to catch the tide at Avon mouth and embark on that terrible old tub the *Assistance* for Ireland, half the men could not get into the stables, and half could not get out of the inns before 5:30 a. m. and so we were nearly an hour late in getting off. Many commanding officers have a good plan of giving a cup of coffee and a biscuit at parade before falling in; the plan I recommend is to have the camp kettles packed overnight with 4 ounces of cheese and one-half pound of bread a man (in a regiment this can be put in the squadron carts); at the half-way halt, pay, water the horses, and let the men lunch, the halt should be made near a public-house and near water, to enable the men to get a glass of beer or lemonade, and the horses to be watered if necessary. From an experience of a long march, I found that very few men drank wayside-inn beer, because it was so bad and so dear; my reason for recommending the half-way meal is, that young soldiers especially, on arriving in billets at say 1:30 or 2 p. m. hot, dusty, and very empty, often drink straight away the two pints of beer allowed them before eating anything, this amount on an empty stomach makes them unfit for work and the horses suffer. If, on the contrary, the men arrive having had a good lunch of bread and cheese, they do not want the beer at once, and even if they take it, it has no bad effect; they are ready to get to work on their horses and when they have done them up, they have their dinners, and enjoy them, with a pipe after as they finish their work.

About fifteen minutes or so after marching off from the place of parade, or when clear of the town, a halt should be made to tighten up girths, and look round; horses invariably empty themselves at first when coming out of stables; also when their backs are cold, will not allow themselves to be properly girthed;

again, some of the men may have been late and hurried, and their kits and gear a bit askew in consequence; but remember on girthing up not to over-girth, a tight girth is as bad for a horse or a deal worse than a loose one; I have seen horses swell up terribly from overtight girthing, and it takes days sometimes for the swelling to go down.

A cavalry regiment or battery R.H.A. should travel at the rate of 5 miles an hour including halts; a field battery about 4 miles an hour. To manage this you will have to shove along, and not waste much time; a twenty minutes halt to water and lunch, and a five minutes halt every hour is all that is wanted on an ordinary march. For the first two days the pace should be a bit slow, about 4 miles an hour, the horses must be accustomed gradually to the work; on a long march about half way before the mid-day halt, I recommend a long trot of 3 to 5 miles at a stretch, and a little longer halt, say half-an-hour to 35 minutes; every advantage should be taken of the road and the state that it is in. To avoid dust, and crowding and checking in rear, sections and squadrons should march independently with an interval of two or three hundred yards, nothing distresses horses more than an uneven pace, which is hard to avoid when in rear of a long column.

When guns are halted for watering or feeding for any length of time, put on the drag-shoes, to prevent accidents. I once knew of a case where three teams got away, and some horses were badly injured; this was not in my own battery. Do not let the horses drink too much, a few goes-down, and a wash-out of the nostrils is all they should get.

If the march be over 20 miles I recommend a half feed being carried and given on the road, but if under that distance this is not necessary; far better for the horses to eat it in the stables where there is less waste.

On arriving at the place appointed for parade or gun-park, usually the market place, the Nos. 1 or sergeants should distribute the billet papers to the men, and direct them as far as possible to where they have to go; the men when broken off will file away at a walk. The guard should mount at once, a guard-room having been rented close to the gun-park or parade. In a battery, the wheeler should with the limber-gunners see that the guns and carriages are all lined and dressed immediately, you cannot be too particular about this being well done, the limber-gunners should take all kits off, and file off to their billets, returning after dinner to wash the guns. The wheeler will be in

charge of the gun-park, and should look to all wheels and fittings daily. The time of arrival is generally between 12 and 2 p.m., the officers having given orders to the sergeants or Nos. 1 where, and at what time to meet them, will go to the hotel where they are billeted, and the sergeant-major and pay-sergeant having received orders as to what time the commanding officer will go round billets, can do the same. The officers should start round their billets about two hours or so after marching in, and see that all is correct, shoeing-smiths, collar-makers and saddlers should go round their sections during the afternoon, to do anything that is required of them, and the former will report all casualties to the farrier. At about 4 o'clock the commanding officer will go round billets with the officers, the sergeant-major, farrier and senior collar-maker, in small towns it is easy to visit all, and I always made a point of doing so myself, but in very large towns, and especially in the suburbs of London, the billets are so scattered that to miss some of the extreme outlying ones might be unavoidable. All casualties should be pointed out to the commanding officer, also anything wrong as to stabling or the accommodation of either horses or men, and he will then adjust it.

I generally made a point of seeing the landlord and of having a chat with him, sometimes there might be a little trouble to be smoothed over, but in most cases this was easily done, I generally found all very willing to please, and in parts of the country where troops rarely go, they were delighted to have them and fête them. The sergeant-major should warn the hour for parade, and arrange any changes in horses as he goes round and the pay-sergeant should pay the billets. If the farrier notices any horse at all off, he should administer a ball as laid down, and see that all small chafes and sores are dressed.

The sectional officers or subalterns should instruct the men, when the saddles are removed, to wisp the backs well over, or beat them with the palms of the hands for five minutes, and then quickly dry them to promote circulation and prevent lumps rising; if the horses can be racked up so as not to roll, it is better to leave the saddles on till after the men have had dinners, and groom the rest of the body first; the non-commissioned officers should examine and feel every back carefully daily, reporting any tenderness at once to the officer in charge; swellings often occur from overtight girthing, especially at the mid-day halt when watered and fed. An overtight girth is a very painful thing to a horse.

I recommend before marching that a dealer's halter be

purchased for each horse (I carried them rolled and folded on the near side), they save a deal of cleaning of head-collars and head-ropes, and the men will be much pleased. The sergeants should report to the sergeant-major again at roll-call at head-quarters.

In case of any disturbance (very rare), or if there be any men or prisoners to be confined, the police will take charge of them, and look after them carefully. I remember in 1880 an old gunner in "C" Troop at Blandford, who had slipped his head-collar, and was creating a disturbance, and whom we had to put in police cells with a cut head. Poor Cumming, afterwards surgeon in the Guards, since dead, and the orderly officer (myself) went to see him, popped a couple of stitches in his head, gave him a drink (an emetic), and left him; in the morning the kindly constable's wife told me that the poor man felt so sick that he could not eat a couple of new laid eggs she had given him for breakfast. A pair of handcuffs or two should be carried on the road.

Billeting is not too popular among landlords, especially in much frequented routes, such for instance as Woolwich to Okehampton, they get too much of it and the pay is not good, but in places where few troops pass through, the landlords are most kind, and the men and horses fare sumptuously. Of course a great deal depends on the behavior of all ranks, and on the tact of the officers and non-commissioned officers. When I marched as a commanding officer at home, I gave the men before starting a little lecture about behavior in billets, and told them that a civil tongue and a ready manner, especially with the ladies, often meant a breakfast in the morning; they evidently took the hint, for I had not one complaint in six weeks, nothing but praise of them from the landladies, and the men were nearly all of them under three years service. The young officers should also try and have a chat with the landlady or landlord at every house, it does good, not only to your men but to those who follow after; I have marched in the wake of corps that have made themselves liked by their courteous behavior, and also in the rear of others that have got themselves disliked by their own rough manners.

As regards the officers' own billets, oficers are apt to forget that 2s. for a bed and a private sitting room is not what the innkeeper is accustomed to get, and that in busy times they may be a trouble and a loss; I have followed a battery where the officers grumbled apparently at every inn at 5s. a head for dinner and drank no wine (possibly they may have been teetotalers). I

think myself one should do something for the house, and for the credit of the army, and in all the batteries I have served with, and marched with, we always had a bottle, and if good, a couple of the best port in the house, and I have unearthed some rare good stuff too in out-of-the-way inns, especially in hunting counties.

Sometimes it was almost impossible to get a private sitting room, and we have gone without to do the landlord a turn, and have been treated none the worse in consequence. With but one or two exceptions, I have invariably been well done and the officers have always parted the best of friends with the landlord and staff. As a subaltern I have a vivid recollection of some old British brandy in the commercial room, at I think the Bear Hotel at Bath, and some whiskey at Roscrea that took a deal of beating, though I had a bad head the next day from either too much or too little of it.

Both officers and men should be made to dress as smartly as possible on the march, and when about the streets, it does a deal of good to the army, also there are lots of old soldiers, both officers and privates, in all country towns who are on the look-out, and it soon gets about as to whether the soldiers be a smart or a dirty lot. I regret to say I have met batteries of R.A. and have heard of a battery of R.H.A. (it must have been a very bad one) of which the officers marched in serges. I also insisted myself on all officers dressing for dinner at the inns, just as they would do at mess.

As doctors do not now accompany troops on the march, a medical practitioner can be called in if required, the man if necessary will be sent to the nearest military hospital by rail; if too bad to move, to the civil hospital; the same in the case of horses; it should be borne in mind by all ranks that it takes but a very few sick horses to disable a battery, and thus every care should be taken to prevent casualties with batteries not on full establishment.

A small dismounted party is allowed by rail daily some 12 to 20 men. The new guard, officers' servants and grooms should go on with the officers' baggage, where there is no railway they must of course ride or march.

In conclusion, as an instance of a successful march, I may refer to that of 66th field battery from Christchurch to Okehampton, three weeks in camp, back to Christchurch, and on the next week to Newcastle-on-Tyne, roughly 680 miles; all young soldiers and three second lieutenants, no horse was left out, only two

men were sent sick, one to Sheffield, and one detained at York; there were no complaints from the police or landlords, not one regimental entry, and not one case of drunkenness on the way, although at some of the places billeted at, a battery had not been seen for twenty years, and in some of the mining towns on Saturdays very nearly the only men sober in the public houses were these young soldiers. What spoke also well for the subalterns, the sergeant major, and the Nos. 1, was that the battery never once moved off parade more than five minutes after the time appointed to start, and nine days out of ten was ready to move off when the clock struck the hour.

MARCHING IN INDIA.

Whereas in England, the men billet and are fed, the baggage going on by rail, in India on the contrary, the men are in tents, and all supplies, light baggage, cooks, servants, etc., accompany them on the road; the preparations for a march in the latter country are thus more extensive, the details require thinking out before starting, tents have to be drawn, carriage requisitioned for, and notices sent to the civil authorities in the districts that your route takes you through, so as to ensure supplies being collected at the different camping grounds; these grounds are all laid down in the route book; care must especially be taken to give due warning to the Durbar officials, when passing through native states, and a probable estimate for all the different supplies should be sent them. A commissariat agent is sent with the regiment or battery to procure and arrange for all supplies, and to pay for all government issues, he cannot always though get quite what is wanted, and it sometimes happens, especially in native states, that the proper supplies are not forthcoming unless early and repeated warnings have been written on through the proper channels; this agent should report daily to the commanding officer at each camp, that everything has been settled up for by him, and that he has the receipts, the head man of the village being present also so that the commanding officer can personally satisfy himself that such is the case.

The best tents for the march are the I.P. general service 160 pounds single fly tents, to hold about ten or twelve men; the E.P. takes too long to pitch, and is too heavy to pack and carry, though when once pitched it is more roomy, and being a double fly tent is much cooler, and decidedly better for a standing camp; in the Madras and Bombay Presidencies, the sun is hotter in the marching season and E.P. tents are more used, still for marching

and camps of exercise the small handy tents are preferable in every way, for in case of rain it is impossible at times to move with E.P. tents, as they become from the moisture too heavy to carry.

The transport for troops varies much in different parts of the country and in different stations. At large stations you may get all mule carts, pack mules, or camels or elephants; it depends much on the district; at smaller stations where there is no commissariat depôt, the transport will consist principally of country carts and camels hired for the march only. In all cases some of the transport will probably be hired carts. Mule carts and pack mules are the best of all transport, they can if well looked after travel almost as fast as the troops, they are easy to load and unload, mules are also very hardy. Camels are slow, they cannot travel in wet and are disagreeable brutes, and none too nice or easy to load. Elephants are also lumbersome, delicate and slow, and country carts, though easy to pack and requiring but little looking after, cannot travel at more than 2½ miles an hour; most regiments and batteries up country keep up a certain mule cart transport of their own, enough for line gear and kit at any rate, if not for the tents. An indent must be made out for the authorized transport, and sent three weeks before the march to the Chief Commissariat Officer to check, as well as that for any private carts required (unless the commanding officer prefers to get his private carts direct through the collector and civil authorities). Half the rate is generally paid in advance for private carriage, and when carts are once taken over, strict watch must be kept over the cart men, or they may bolt, for many are impressed and don't care for the job; a number of private carts are always wanted for officers, canteen stores, sergeants' mess, coffee shop, master tailor, syces, native followers, etc., etc.

The transport will be collected by the commissariat authorities, and handed over the day before the regiment or battery moves; the transport officer (in a battery the captain) should take it over, and with the quartermaster sergeant detail it all to the different units, giving the subalterns and sergeants an exact list of the transport apportioned to their commands, with instructions as to how everything is to be carried. A senior non-commissioned officer should look after all commissariat transport, the regimental transport of a battery has a non-commissioned officer already in charge, and that of a regiment an officer. A guard should be detailed daily, in a battery of from five to six men, to accompany the baggage on the road.

The best and quickest means of transport, such as mule carts and pack mules (if the transport supplied is mixed, as is generally the case), should be taken for the line gear, the men's kits, cook's traps, and things that are first required on arrival. When marching with other corps it is wise to have a distinctive mark or color for your own regiment's or battery's baggage, some regiments have small flags on the carts, etc., but colored puggaries for the native drivers answer better as they do not so easily get lost, and they have the additional charm of pleasing the natives hugely, especially if made of a good striking color. The tent bags should all be labelled with the number of the section or sub-division, painted on large leather labels securely sewn on; and the mule carts or camels told off every day to do the same work and in the same place.

The government and private transport, with the exception of officers' private carts, etc., should be parked in a place told off daily, and the feeding and watering of the animals carefully seen to; the farrier going round and inspecting all the animals at each camping ground.

The quartermaster sergeant with the camp color party, and the grain grinding machines should proceed the afternoon before to the next halt, to lay out the camp, draw supplies and get everything ready.

In a regiment the quartermaster of course may be in charge of the advance party. The camp grounds and horse lines being marked out with thin cords and large and small flags (regimental colors). He should see to the rations (men's and horses'), get the grass in, or procure what he can in lieu of it if very bad; he should make arrangements for watering, damming up a nullah, hiring bullocks to fill a trough, if there be one, or what not (a few canvas drinking troughs should be carried by each squadron or battery, they are most useful), he should see cooking places marked out; the cooks go on ahead every afternoon under the cook orderlies, so as to be in time to prepare breakfasts. It is well to give the cooks the quickest and best carts of the transport and every advantage you can, for much depends on them. In my battery I have a spring cart into which I put a horse to carry the cook orderly and cooking gear, but a mule cart is as good or better.

The quartermaster sergeant should arrange about water for drinking, and set up filters which he carries on with him, and the conservancy men under him will see to the digging and marking out of the latrines, these should be marked out by flags,

a portion of the regimental conservancy establishment marches with the advance party.

He should send for letters if there be a post office and in fact make all arrangements possible. The regiment or battery will probably march in about 11.30 a.m. if the roads be good, or perhaps a little before; the breakfasts should be ready about three-quarters of an hour after that time; the quartermaster sergeant however will get instructions daily from the commanding officer at about what time to expect him.

The time to start is about 8 a.m., not before 7.30 at earliest, unless the march is known to be a very long and tedious one, or there are more troops on the road; it is bad for both men and horses to start earlier, neither is anything gained by so doing. When I first marched in India in 1875, in the Bombay Presidency, there was an insane habit of starting at 4.30 and 5 a.m., in fact in the middle of the night. I never knew why, perhaps the doctors ordered it; I believe in those days regiments always paraded about that hour; now, thanks to Sir George Greaves they know better; of course in those parts, or in Madras, if marching very late in the season, you might perhaps start at 6.30, though personally I am against starting before 7.30 unless under special circumstances.

Any man, whether white or black, should be punished who hammers a tent peg, or makes a noise before reveille sounds, unless this is done you will have the men and syces hammering up pegs, and harnessing up horses before 5 a.m. and there will be no rest; on no account either should a horse be stripped, or a saddle put on, before boot and saddle sounds, half-an-hour before the time to march off; fifteen minutes after reveille, feed should sound, the tents should then be struck by bugle call, and packed; an hour gives ample time to do all. The camp ground should be cleaned up, and straw and rubbish burnt by the rear-guard, who should see this carried out before moving off.

The coffee shop should go on half-way over night, so that the men can obtain a cup of hot coffee and biscuits or cake at the halt. The plan I recommend is to halt and look round, if necessary water and feed (but this only on long marches), and then for each sergeant or No. 1 to send a non-commissioned officer and a man to draw coffee and cake, etc., for every man in his section or sub-division; the coffee and cake is all put out ready in cans and baskets, with three or four pannikins per sub-division by the man in charge of the coffee shop, he having the night before received intimation of the number per sub-division; this

saves the men leaving their horses and avoids crowding or fuss, a man will at the same time go round the battery with extras and cigars; the mess can arrange for the officers' coffee or tea, etc. to be at the same place. I pay the coffee shop, and pass it through the men's accounts at the end of the month. The coffee shop then packs up and moves on quickly to set up in camp, a portion having already gone on ahead. Before starting on the road, the officer in charge of the coffee-shop should make arrangements for a good stock of tobacco, cigars, cheese, bacon, soda water, lemonade, etc., to carry on the road, and also on a long march, that consignments meet the battery at places where the camping ground is near to a railway station; a well organized and furnished coffee shop is a great boon on the march.

The canteen will make similar arrangements for beer, this can generally be done, as now the trunk roads are always meeting the lines of railways. Rum being easier to carry than beer, a certain amount of it can be taken if there is any possibility of being a long time distant from the rail.

On arriving at the camping ground, the lines and gun-park will be found already marked out by the quarter-master sergeant, also the places for tents, the regiment or battery then draws up on the ground allotted for parade or gun-park, and proceeds to water and picket; a battery draws up its guns in line, the wagons covering them (small flags having been placed to mark where the points of the shafts should be for the guidance of the drivers), unhooks, and while the drivers and horse-holders file to water, the duty numbers lay down the picket ropes, lines of white cord having been pegged out for them to follow, the sergeants taking care to dress all the picket posts and heel pegs correctly. I carry a spare set of strong iron posts in my battery, also serviceable heel pegs, and a few iron mallets, as the Government issue knock up in a day or two. The horses then file on the lines, and are tied up by their head-ropes until the line gear arrives, which it should do in from twenty to thirty minutes, that is if conveyed on mule carts; after filing on the lines a little grass should be given at once to each horse to keep him quiet until the line gear comes in; the men then roughly groom the horses over, and take off kits, in about fifteen minutes the order "off saddles" should be given, and the horses' backs sharply wisped, or beaten with the palms of the hands and well dried to promote circulation, and to prevent heat lumps rising, the blankets should then be folded over the loins if hot, if cold the horses should be blanketed up, and the men turned out for breakfast, having

previously given the horses their feeds, these will all be mixed and prepared, as the line orderly and his party will have come on overnight; the grass and grain crushers, etc. will be in the center of the lines at the end. Allow an hour for breakfasts and then turn into stables, if the tents are in put them up first; this should be done by the orderly officer, as laid down in regulations. Dinners will probably be ready about 3 or 3:30 p. m., according to the hour the regiment or battery marched in. Stables and water between 4 and 5 p. m., then feed, give the last feed about 8 p. m. and with it a good proportion of the day's grass, it keeps the horses quiet at night. The quarter-master sergeant and party should move off about 2:30 p. m. and the cooks about 4:30 p. m., one or two of the latter being left to serve up teas.

Gram is generally easily obtainable and good, but bran may be hard to procure. On the Madras side you may have to take cooltic, which must be boiled, boosa or chaff can be often obtained, and serves instead of bran; grass is very often bad and very hard to get, in which case kirby or chirrie, the stalks of jowari, and bajqri, or sugar-cane are fairly good substitutes. There are several grains that can be used in emergencies, barley, Indian corn, mote, barjree, urreed, etc., these can often be obtained in the villages. If half a feed be taken on the road, it is deducted from the morning feed; when marching off trunk roads and on cross country tracks it is always wise to carry a half feed; I have personally had experience of some very rough roads in Khandeish and Rajputana, and once or twice spent a day or more crossing a river.

A veterinary surgeon marches with a regiment but never with a single battery, the farrier in his absence should take his place as far as possible, and the commanding officer should see the veterinary history sheets are kept up to date, very sick horses can be sent in by rail (if near a railway station) to some military hospital. The farrier should carry a good supply of ready mixed drinks, and also the ordinary medicines to make up on the road, a good stock of bandages, carbonate ammonia, ginger, vaseline, and simple dressing, antiseptics, etc. He must arrange to carry some charcoal for the field forge, and a certain amount of iron for shoeing purposes, his forge will be set up daily in the place told off for it, if possible under a tope of trees, where he can carry on his work protected from the sun; as there is always Sunday's halt, and one day a fortnight besides, he has ample time to keep the shoeing up to date; charcoal and iron can nearly always be purchased in the larger native bazaars on the road.

The saddlers, collar-makers and wheelers and other artificers will have a tent pitched for a shop, the former will probably have a good bit to do, and must draw their supplies from the store wagon as required. The wheeler has charge of the gun-park in a battery, and should dress all wagons at once on arriving in camp, he should examine every wheel throughout daily, and see that they are cleaned and properly greased.

The officers' mess should have two sets of tents, one to go on ahead every night, and the other to stay till after breakfast next morning, and then to follow on, for the same reason also nearly a double supply of servants is required, it is also essential to have a first-rate cook, or better still two for the march.

A good supply of stores, wines, etc., must be laid in and carried on carts, arrangements must also be made to pick up fresh supplies at railway stations on the road, also with the postal authorities to send on letters and papers; a list of post towns, with dates of arrival at each, should be furnished to the postmaster before leaving for his guidance.

A native banker usually accompanies regiments and batteries on the road, and he carries money which should travel under guard; in case of his not accompanying them, the money will be carried regimentally also under guard, the money being placed every night in the guard tent under a double sentry. A native banker however saves a great deal of trouble.

A good supply of oil must be carried on the road, though kerrosene oil is obtainable in nearly all bazaars. Each tent should be supplied for the march with a strong hurricane lamp, these lamps should be filled and trimmed daily by one man detailed by the quartermaster sergeant for the job, he is generally the same man who superintends the filters and conservancy. In a standing camp large lamps placed at intervals of twenty yards up each side of the camp, outside the tents, and with the number of the regiment or battery painted on the glass, are very useful.

Chowkidars or watchmen should be obtained nightly, the head man of the village is obliged to supply them free of cost, it is a form of blackmail, but still if chowkidars are not employed compensation in event of robberies will not be obtained. This holds good in native states especially, but there they may have to be paid for.

In rough countries where marching is often done on cross country tracks, it may be necessary to have a guide, he should also be obtained from the head man of the village.

Marching in India may appear on paper to be a more tiring and tedious business than marching at home, but after the first few days when the men have learned to picket, pitch tents and the routine, and the transport and all ranks know their places, the work is really less for both officers and men than it is on a march in England; camp life is good for all ranks, and enjoyed by all for a period, if the weather be fine, there are no inducements to drink, and the sport and shooting obtained on the road give great amusement to everyone, the men also learn more real soldiering during a month in camp than they do during 6 months in cantonments. The people who have a rough time, and are hard worked are the syces and followers, they are however as a rule a cheery and hard working lot; their wages being very small, every consideration should be shown them, such as giving them (out of the funds) a cart or two for their traps and kits, and a few spare tents if there be any to shelter them in case of wet weather. In concluding I must apologize for having spun out this paper to a greater length than I had originally intended, but many small details struck me in writing, all which may be useful as a guide to some. I have laid down no new theories, the whole is an old story, but as I constantly meet men coming out as Majors and Captains to India, who have never served in it before, any small hints will be acceptable to them I feel sure.

PROFESSIONAL NOTES.

A. ORGANIZATION.

Royal Artillery—England.

It is not our present purpose to consider minor reforms, but to plead for the total separation of the mounted from the garrison artillery. That is the first step towards every other reform; it is the absolutely essential condition on which the continued efficiency of our artillery service depends. As already indicated, several influential officers have opposed the idea, probably owing to their great admiration for the past of the regiment and their loyal faith in its future; but we would submit that if the *status quo* be maintained in the face of new requirements, and in the midst of altered circumstances, the artillery will be heavily handicapped, and the other arms will not have the co-operation which they have the right to expect from it. These views will not appear to be extreme if due weight be attached to the following considerations. As the efficiency of a field force and the success of its operations depend so largely on the state of its artillery, the latter cannot be too highly trained or too frequently practiced in conjunction with cavalry and infantry. When the artillery is well officered and well horsed, when it is noted not only for the accuracy of its fire but for its mobility, and the quick intelligence with which proper positions are taken up in support of the other arms and in pursuance of a general plan, it fulfills its mission and creates universal confidence. But how arduous is the path which leads to this standard of excellence, and how few opportunities superior officers have of commanding their batteries or brigade divisions in a mixed force. And yet it is principally by continued trial and practice that faults are discovered and perfection attained. A field artillery officer should be a first-rate horseman and horse master, as well as a collar maker and farrier for all purposes of supervision, a thoroughly instructed and expert gunner, a strategist to a certain extent, and an able tactician. He must have an eye for country, a quick wit for taking in a situation, and be the trusted leader and friend of all under his command. We have many artillery officers who answer this description, but we want many more, and it is only by making and retaining such officers that our field artillery will continue to do us credit as it has in the past.

In the first place, the officers who prove themselves equal to the duties of field artillery are fitted by nature and inclination for their position. In the next place, they require all the experience, practice, and training which they can possibly obtain to make and keep them the ideal artillery officers of an invincible British field force. Why, then, are they ever and anon removed to a sphere for which they have no training and no aptitude? If it were desired to ensure defeat and disaster no better means could be employed than the removal of efficient field artillery officers from their proper sphere. If they were simply removed the mischief would be the less, but they are transferred to the garrison artillery, where they are worse than useless. Their heart is not in their work, and they are painfully aware that they are

in a false position. The officers, non-commissioned officers and men of the garrison artillery have lived laborious days and years in mastering the scientific details of the big guns and ordnance machines by which they are surrounded. The field artillery officer, so far from taking up his place as the superior of the garrison gunners over whom he is set, is conscious that he is inferior in technical knowledge to the last made bombardier. All this is doing gross and flagrant injury both to the garrison and mounted branches. Common sense and the all but unanimous voice of the regiment demand a change which we hope will not be much longer delayed. The necessity for the change will be more apparent when it is stated that officers who have just become what may be termed completely proficient and trustworthy as leaders of artillery in the field are promoted as captains and majors into the other branch, in which they are quite inefficient. This involves a loss of power and a waste of money which can surely be comprehended by the dullest of taxpayers and the most tape-tied of officials.

—*Army and Navy Gazette*, October 12, 1895.

Royal Artillery—England.

Asked to account for her existence, Topsy replied, "'Spects I grow'd," and an answer to the same effect would, it seems to us, have to be given to anyone seeking similar information regarding the organization of the Royal Artillery. Be this as it may, a far more important question which remains to be considered is whether the present organization should be maintained or whether the regiment should be split up in accordance with obviously possible lines of cleavage. It is well, in this connection, to remember that the Report, published in 1888, of the last of the series of Royal Commissions on the Organization of the Royal Artillery, consisting of Lord Harris as chairman, and seven members, shows that of the thirty-four witnesses examined nineteen advocated separating the Royal Artillery into two or more distinct bodies. Eventually a proposal was submitted to the Commission by one of its members, which some of the other members considered to involve separation; and on a division being taken, the Commission was found to be equally divided. The four dissentient members recorded their reasons for dissent in a Minute, and a very valuable contribution to the controversy is afforded by the detailed and careful examination to which some of the paragraphs of such Minute are subjected by Lieutenant-Colonel Hime, R. A., in a recently published *brochure.** Into many of the questions proposed by him we do not propose to enter, but on others we venture to offer a few observations.

Though it certainly is no sufficient reason for delaying any reform that may be shown to be necessary in our own service, there is a certain amount of satisfaction to be gained from the knowledge that the artilleries of the Continental States—except, perhaps, Germany—are quite as unorganized as our own, and that the histories of all of them correspond closely in their broad outlines. Beginning from small beginnings, the artilleries of Europe advanced but slowly during the first four centuries of their existence owing to the slow advance of chemistry, metallurgy, and the mechanical arts, on which their progress essentially depended. Since the beginning of the present century the progress of these arts and sciences has been wonderfully rapid, and the various artilleries have consequently increased in size and complexity in a corresponding degree. It is vain to look for the rudiments of

* "Artillery Reform," by Lieutenant-Colonel H. W. L. Hime (late) Royal Artillery. (London and New York: Longmans, Green, & Co.)

organization in any European artillery, with the possible exception of the German. They are not disorganized, because they were never organized. They are, as Colonel Hime well expresses it, unorganized. Austria, France, Italy, and Spain continue, like England, to adhere to the system of a single corps of officers—that is, as the gallant Colonel observes, these countries have not yet taken steps to organize their artilleries.

Passing by some of the objections that have been raised to "separation," we are met by the very pertinent question, Why insist upon separation if so many good officers are left, under the present system, in the garrison artillery? Colonel Hime's answer is, we think, all sufficient. Good officers were, he admits, left; but he points out that they were left with a sense of inferiority—a feeling of disappointment. They had been passed over, they were rejected. By passing over officers of the garrison artillery, the authorities gave them to understand they were looked upon as inferior to others, and this of necessity must have prejudicially affected them more or less according to their moral strength. To say the least, it must be agreed with the gallant Colonel that it cannot be regarded as an incentive to exert their best energies in their duties.

But the gates of hope are not closed irrevocably against the garrison artillery officer. The report itself, to which we have before alluded, expressly declares that the fact of an officer serving in the garrison artillery has never stood in the way of his appointment to the horse artillery; or, in the words of Colonel Hime, "an officer of the oldest and most scientific branch of the artillery is bribed to raise his men to a high state of efficiency by the prospect of immediately leaving them—until promotion, at all events, and probably for ever." Well may he exclaim: "Never before among the rational sons of Adam was such a system tolerated;" and ask what would be the state of our splendid rifle corps were their best officers selected for the hussars: of our fusiliers, were their best officers selected for the dragoons? Yet, as he observes, the garrison artillery is first ransacked for officers for the horse artillery, and then ransacked again for officers for the field batteries. A peculiar point is that, although ever recoiling from any salutary reform in principle, the authorities have never showed themselves averse to alterations in detail; and repeated "reorganizations" have swept over the regiment since 1870, which have all begun and ended in merely changing the names of batteries. One unfortunate battery known to Colonel Hime changed its name, it seems, three times and its equipment four times in a little over three years.

It has been said that if the garrison artillery be separated from the field, no one will go into it. No one of course, it may be at once freely admitted, who can help it will now go into the garrison artillery; no one, as Colonel Hime observes, in possession of his senses, will willingly enter a profession to which the stigma of inferiority is attached—a profession in which there is no reasonable return for the work he does and the hardships he suffers—a profession in which the chief reward of merit consists in being bodily removed from it. There is much in the gallant Colonel's contention that there will be no dearth of officers when the stigma of inferiority is blotted out by complete separation from the field artillery, and when the officers gain the position that befits officers of the first arm of the artillery service.

Supposing the garrison artillery to be formed into an independent corps, the further point remains to be decided whether the Royal Horse Artillery

and the field batteries are to continue under the present system. We are inclined, on the whole, to agree with Colonel Hime that the arguments against unification seem to be insuperable, and that nothing would remain but separation of the field artillery into two independent bodies as distinct from each other as the garrison artillery would be from either. The proposal that the Royal Horse Artillery should retain their present distinctive dress, equipment, and titles is one that must necessarily meet with general approval; but we can see no sufficient reason for, as further suggested by Colonel Hime, following the analogy of the light and heavy cavalry and dressing the field batteries in the national color—red. Nor does the gallant Colonel lay any stress on this latter point. This much must, however, be conceded, that whatever the dress of the field batteries it ought to be perfectly distinct from that of the horse artillery, were it only to enable the two services to be readily distinguished in the field.

With the artillery formed in three separate and distinct bodies, the officers having been taken as they stand on the present senority list and placed upon three separate lists for promotion, it seems to us there is no sufficient reason for further subdivision or organization into so-called regiments, and we fully concur with Colonel Hime's view that artillery regiments would merely add a fifth and most embarassing wheel to the artillery coach. They would be a needless piece of over-organization, and in an army over-organization is, as the gallant Colonel pertinently remarks, worse than under-organization. No system of "regiments," it must be granted, possesses the simplicity and flexibility of the three large corps proposed which could, as claimed, supply a force of artillery suitable to an army of any strength, destined to operate in any country, without confusion, difficulty, or delay.

—*United Service Gazette*, November 23, 1895.

B. TACTICS.

In a lecture delivered before the military society of Moscow by General Tikhobrasow, on the subject of the *use and the action of artillery masses in battle*, the following statements occur:

From the nature and character of the 15 cm. mortar it follows that on the battle field this gun cannot form a constituent part of the artillery masses, either during the preparatory firing or during the actual artillery combat. This is so for two reasons: 1. Because mortar batteries, as actually opposed on the field to an enemy's gun batteries, will be much inferior in regard to rapidity of fire; 2. Because it is poor economy to expend ammunition, which, on account of its weight, must be limited in quantity, to attain results that can be just as well attained with lighter projectiles. Moreover, when the time has come to prepare for the final assault and the gun batteries are already somewhat weakened, all the support possible will be demanded and expected from the mortar batteries. For these reasons the artillery masses, according to Tikhobrasow, must still be composed exclusively of gun batteries, the mortars remaining in reserve. Only when the battle has assumed a definite form, and the point of attack, the breach in the enemy's line, has been definitely determined, then and not till then is the time to bring the mortars into position.

—*Russian Invalid*, No. 19.

Field Artillery Tactics.

The important question of the armament of the field artillery in the future

has not yet been definitely settled; but views on the subject have become more and more clear. It may now be asserted that the field gun of the future will by no means be a small caliber Q.F. gun with little effect from the single shot. The trials held in various countries have been enveloped in an impenetrable cloud; but the military periodical literature, which affords a pretty true representation of general opinion, has during the year not been favorable to the light field Q.F. gun.

Every State is busied with the re-armament of the field artillery; none likes to make the first move, but all are making preparations for the introduction of an improved pattern in the event of anyone of them taking the initiative.

The question whether the best advantage is to be derived from direct or indirect fire, so happily solved by the German Field Artillery Drill Book, has been much discussed in the periodical literature. The German regulations (page 276) lay down the principle, that direct aiming continues to be the greatest desideratum in the selection of the artillery position. This alone does not in itself warrant the conclusion that direct fire has the advantage over indirect fire, but on page 274 this is distinctly expressed. Indirect fire is restricted to the cases in which the ground or the situation does not admit of direct fire being employed. Notwithstanding this, much has been said on behalf of indirect fire. In this view it is assumed that artillery can shoot as well indirectly as directly, but that with direct fire such losses will be incurred as must within a short period of time result in incapacity for further action. There is a mixture here of the true and the false. It is correct that a well-trained battery, under an able leader, will be able to shoot really well indirectly; but this does not mean that it will shoot equally well, or even better, indirectly than directly. The experiences of the practice ground prove little; for there only a single battery fires indirectly, and even if, exceptionally, a battery formed as part of an artillery division has to fire indirectly, the task is so arranged as not to offer too great difficulties. The difficult point in direct fire lies essentially in the observation, especially of lateral deviation. So long as one battery only is firing, the difficulty does not really arise, for every burst will be due to projectiles fired by it. But the moment there are several batteries firing together it becomes very hard for the observing battery commander to distinguish the shots that fall with strong lateral deviation from those of other batteries; indeed, it may at times be said to be quite impossible. It is possible only when both the observation and direction of the fire are personally conducted by the battery commander.

In our opinion, the German regulations indicate the only right course. When the conditions do not necessitate the employment of indirect fire, preference should be given unreservedly to direct fire. But as circumstances may, against our will, force us to use indirect fire, we must make ourselves thoroughly familiar with it and practice it in peace time. The main consideration in a fire position is view; after that only is the endeavor to obtain cover from the enemy's view legitimate. To do so it is not necessary to creep up behind ridges or hedges; with smokeless powder even small bushes, etc., between which the guns are placed, offer an excellent screen.

A third question that has been much discussed is that of the employment of horse artillery in combination with cavalry. This refers especially to the preparation of the attack against cavalry, for as regards the great value of the employment of horse artillery in reconnaissance service there can scarcely be two opinions. Since the appearance of von Hoffbauer's and von Schell's

works on the subject, eighteen and fifteen years ago respectively, this question has not been so thoroughly gone into as it has in the past year in the *Journal des Sciences Militaires* and the *Revue Militaire Belge*.

The writer of the paper in the *Journal* starts from the principle that the batteries allotted to the cavalry division must remain united, and can only come into action on one flank of the division. This view will be generally accepted, though in hilly ground that favors firing over one's own troops, a position behind the division might be thought of. The position should be about 500 metres from the line on which the collision of the cavalry is to be anticipated, and so far to the flank that the division will not be interfered with in its deployment, therefore, about 200 to 250 metres.

The position must be so chosen that it can be taken up as early as possible; if the two lines of advance of the cavalry form an angle, the artillery position should be preferably inside this angle.

By this means the artillery will interfere as little as possible with the movements of its cavalry, it remains in the closest connection with it and is itself sufficiently protected by its situation; from thence it can take the enemy's lines in flank and continue its fire up to the latest moment without being masked.

Everything depends upon the artillery reaching this position at the right time. As they can only occupy it when the divisional commander gives the order to attack, only a few minutes will be available for the purpose. Consequently, the artillery must be already in preparatory formation at a spot as close as possible to the contemplated position; otherwise it cannot be practicable to open fire at the right moment.

If the place accorded to the artillery is 300 to 400 metres before the front, and 200 to 250 metres to one side of it, it will have only about 600 metres to pass over to reach the fire position, and will be able to open fire within about two and one-half minutes from the order being given. The artillery should conform to any movements of the division in preparatory formation, in such a manner as to admit of it participating in the engagement at any moment.

The place thus indicated for the artillery has the advantage that the spheres of action for the artillery and cavalry are separated, so neither arm runs the risk of being impeded by the other, and each one can be utilized as long as possible.

The artillery is there also sufficiently protected, for the entire division is in a position to act at any moment. Patrols to its front and outer flank, as well as a special escort, take sufficient care for its safety. But, even if the position should be somewhat exposed, there must not be any hesitation in taking it up, for there are no other means of ensuring the timely intervention of the artillery in the engagement. The artillery is always the prey of the victor; it best cares, therefore, for its own safety by contributing to the extent of its powers to the victory of its cavalry.

Looking to the short duration of the cavalry engagement, it cannot be the task of the artillery to cause great losses to the enemy, it must rather endeavor to bring the enemy temporarily into an unfavorable condition, which must be utilized by the cavalry leader. This can be done equally by means of an effective fire, or by drawing away on itself part of the enemy's force. An artillery division can only be endangered by a pretty strong body of cavalry, the withdrawal of which from the attack may be of decisive importance for the result.

The commander of the artillery is always with the divisional commander ready to receive his orders. In cavalry engagements so much of the unforseen occurs, that the procedure of the artillery can never be definitely laid down beforehand. If this close connection is not maintained, either the artillery will receive their orders too late or not at all. An orderly may deliver them incomplete or incorrect. And further, between the time an order is given and that at which it is received, the situation may have so changed that it will no longer apply. The distance of 300 to 400 metres in front and 200 to 250 metres to a flank of the first line is sufficient not to impede the freedom of movement of the division, and yet not too great, so that all orders can arrive at the right time. Also the artillery can conform easily to all changes in formation and in direction. The cavalry can, therefore, maneuver without regarding the artillery, and can at the same time count upon finding it ready to participate in the engagement at the right place. The distances will naturally vary somewhat according to circumstances; in covered and difficult ground they will generally be rather less; in open clear ground, rather greater.

The separation of the artillery from the main body of the division is only justified in exceptional cases. It is generally not expedient to attach artillery to the advance guard. This could only be permissible in the case of it being required to push artillery rapidly forward into a position with a special object. But in that case the advanced guard would be really converted into an independent detachment; its own proper task is observation and security, in which the artillery cannot participate. Artillery attached to an advanced guard must either fall back with it on the division, in which case the advance secured has to be abandoned again, or it will open fire prematurely and without having a knowledge of the divisional commander's intentions, and so force him perhaps to enter into an engagement under unfavorable conditions.

Exactly similar grounds exist for not sending artillery forward too early into an intended position. In a cavalry engagement the considerations that usually decide the choice of an artillery position are not applicable; here it is only a question of commanding the field of attack by fire. A position then, however excellent from a topographical point of view, is of value only if the engagement comes off in a certain definite manner. But as this depends half upon the enemy, things may result quite differently from what has been anticipated. It is, therefore, generally a mistake to assign a definite position to the artillery too early.

GERMANY.

At the field artillery practice last year, the new shrapnel (c/91), which unites in itself the advantages of shell and shrapnel, was used by the troops for the first time, as also was the high explosive shell with white smoke. Both projectiles facilitate the shooting, for a change of projectile is not necessary after determining the range.

FRANCE.

Following the example of Germany, the number of horse artillery batteries has been reduced from three to two. This measure is differently viewed by the French military press. In Germany opinions are also very divided on the subject of the number of batteries it is desirable to have with a cavalry division. Immediately after the war of 1870-71, three batteries were always allotted to cavalry divisions for their exercises. Later on the number sank to

two, and finally there have not been wanting those who say that one battery is enough, and more than enough. Now, as is known, a division of two batteries is allotted for this service. On the other hand, men like Prince Hohenlohe, von Scherff, von Schell, have declared three batteries to be necessary, and also it may be deduced from von Verdy's classical studies in the leading of troops that two batteries are not sufficient for the reconnoitring duties, for in the course of the operations of a cavalry division furnished with two horse artillery batteries a field artillery battery is added to them.

For the actual cavalry fight twelve guns are, in the opinion of the writer, rather too many than too few; for it is only in the rarest cases that they are able to do anything. The real object in attaching horse artillery to cavalry divisions is to act as a support in their reconnaissance service, especially in actions for localities. But as the brigades may very well be sent by different routes, and it can never be known with certainty where hostile artillery may be encountered, the distribution at the rate of one battery per brigade would seem to be the best. That three batteries of six guns, together about 60 vehicles, for a cavalry division of 3,600 horses, is an impediment to movement is recognized; but looking to the rapidity of fire and effect of the modern gun, there is the alternative of reducing the number of guns in the battery to four. We should decidedly prefer to have with a cavalry division three batteries of four guns rather than two batteries of six guns, and the ammunition wagons might be still further reduced.

—Translated from Von Löbell's Annual Reports, in the *Journal of the Royal United Service Institution*, December, 1895.

Austrian Experiments in crossing the Theiss with Cavalry and Infantry.

At the last grand maneuvers held in Hungary several different means of crossing the Theiss at Zenta on the 18th and 19th of September, 1895, were tested. It should be noted that the river at Zenta—where, in the battle fought in its vicinity on the 11th of September, 1697 (a splendid victory of Prince Eugene over the Turks), a pontoon bridge erected by the latter, and which had become of great importance to them, played an important part—at the time of the exercise was 200 meters broad; the velocity of the current was 0.5 m.; the temperature of the water 54°.5 F.; the character of the shore favorable, except that the ground was somewhat slimy.

Of all the means of crossing tested, the folding boats used in the German army proved the best and most reliable. It is said of them, for example, that "as with every new thing, there may be many a sensible improvement possible, such as simplifying their mode of packing and transportation," but —"anything better can hardly be expected." The four-horse wagon, which is designed to carry two folding boats, is, however, regarded as too heavy. Moreover, small detachments cannot use it (as was proposed) to cross streams, because it is not always available for that purpose. To serve this purpose two other devices were used by the two hussar regiments of the active army who took part in the experiments, viz: rubber tubes designed by Lieutenant Colonel Erbes, and so-called Abel floating bags. The equipment with rubber tubes was rejected as entirely impracticable, because the inflating of the tubes with air proved very difficult and took a great deal of valuable time; besides, it was not considered advisable to load down the horseman with an article of equipment, which it is very doubtful he will ever use, is moreover, very difficult to preserve from deterioration and to keep in order for any length of time, and, finally, has no other application or use whatever. The floating

bags carried by the Szegedin Honved (the landwehr of Hungary) Hussars, who also took part in the exercises, were regarded as far more advantageous —they were made in a modified form according to the design of Honved Captain Bekessy—but they were not tried, a fact much to be regretted because in a former trial they had proven quite satisfactory. They resemble the haversack in use in the army and are used as such, but are made of water-proof material. The Abel floating bags proper are somewhat larger than those of Bekessy. In order to be used as floating material they receive a filling of hay, straw or some similar substance, and in case of need the horse blanket may be stuffed into it; with four such bags, by means of three sabres and foraging lines a raft is built on which saddle, bridle and the soldier's equipments are loaded; the men sit astride the bags and the horses swim alongside, held by the halter. The raft is sent out into the stream by means of a rudder or a long staff until the horses lose their footing, after which they will generally carry the raft along quite rapidly in the direction in which the rudder or the staff first started it. From the moment of dismounting to the completion of the raft required eight minutes, and the same interval of time was required from the moment the raft was ready up to the instant of starting off again after landing on the other shore. The Honved cavalry also used pieces of tenting in the same way as the haversacks were used.

Flat boats, invented by Orel were also tested; they were made by stiffening large bags of water-tight materiel with wooden or iron rods, so as to form a rectangular boat, capable of carrying twelve or fourteen men with their equipments.

The crossing of the horses was attended with much difficulty, due to various causes. While being held fast to the side of the means of transportation they were inclined to swim down stream, because they wanted to remain close to the nearer shore, and the rudder or the raft was too weak to overcome this tendency effectively; everything, therefore, depends on starting them in the right direction for the opposite shore; when they have once taken this direction they follow it eagerly.

In other cases the horses were driven into the water in herds of fifteen to twenty by naked hussars provided with whips; they were very apt, however, as soon as they were beyond the reach of the men, to return to the nearer shore.

For crossing the artillery the folding boats were used. A pontoon made of two of them carried a gun complete with limber, cannoneers and harness. The horses were ridden as far as possible out into the stream by the artillerists, who, provided with swimming bladders of pigskin, were mounted on them; when it seemed certain that the horses would reach the other side by themselves, the riders returned to the nearer bank. But in this case also entire troops as well as single horses, often returned to the shore from which they had come.

On the second day of the exercises a life-saving detachment of twenty pioneers (field engineers), equipped with ten hunting boats, was called in for the purpose of effecting the crossing of a brigade of hussars counting eleven squadrons; in addition, one large and two medium sized barges, a wooden raft and ten boats or skiffs, partly manned by civilians, were used; each barge and the raft conveyed from fifteen to twenty horses (swimming at the side) at a time, the skiffs and boats being used mainly for driving the herds

and to catch horses which had broken loose. In five and a half hours the entire brigade was taken from the left to the right bank of the Theiss.

—*Militär-Wochenblatt*, December 11, 1895.

C. ARTILLERY MATERIEL.

a. Guns and Carriages.

The Efficiency of Modern Guns.

At the annual meeting of Sir W. G. Armstrong, Mitchell & Co., the celebrated gun and ship-builders, Lord Armstrong in his annual address, in commenting on the results of the use of their guns in the Chinese-Japanese War, said:

"So far as we have heard, no single gun was rendered unserviceable except by the enemy's fire; and in one instance where a gun received a direct hit and was dismounted, the breech mechanism was still found to be in perfect working order. We have received very flattering recognition of services rendered, together with important orders for further supplies unvaried in pattern. Thus the prediction so commonly expressed—that, however efficacious the refined and elaborate mechanisms of modern artillery might prove in experimental practice, they would be found disappointing under the exciting and rough usage of actual war—has by this experience been completely falsified, and the possibility of a return to simpler and less scientific constructions has been put entirely out of the question. The first elements in the success of the Japanese were undoubtedly their superior scientific training, organization and discipline, without which the finest weapons cannot count for much. But after due account has been taken of these qualities, the victory of Japan on the sea must be attributed chiefly to the wise foresight of her naval authorities in arming their ships with quick-firing guns. One gun of this type represents a battery of several guns of the old type, and as now constructed by us their range and penetrative power are unsurpassed. The Japanese, in regard to armament and naval materiel, kept themselves not only abreast, but, if anything, ahead of their times, and recognized the value of the modern weapons as utilizing to the utmost the higher velocities and lower trajectories rendered possible by the use of cordite. This increased power of guns enabled them to operate at a distance too great to permit of effective reply. The carriages of these guns also deserve some special mention. They are highly finished scientific instruments, utterly different from the rough wooden carriages in vogue not so very long ago, which required twelve or fifteen men to maneuver them. Guns of ten to twelve tons weight that no one in the old days would have thought of placing on board ship at all can now be trained and elevated easily with a single hand, and, in spite of what might be supposed to be the delicacy of the contrivances by which such results are obtained, no single carriage was disabled in the late war except by a direct hit."

—*American Engineer and Railroad Journal*, November 14, 1895.

b. Armor and Projectiles.

Armor.

STOCKHOLM, DECEMBER, 1895.—A ship's armor-plate made by Schneider & Co. in Creusot of homogeneous steel 25 cm. (9.84 inches) thick was recently tested. Three 15 cm. (6 inch) Finspong projectiles of chrome steel were used (weight 44 kg., striking velocity 560 m. : sec.). The first shot remained

unaltered and bounded 13 m. from the plate, the second was upset and bounded 14 m., the third was also upset and bounded from the plate 33 m. to the rear. The plate itself showed indentations 27 cm. (10.6 in.) deep, in front projecting bulges of 3 cm. behind, but no crack. The commission was highly pleased and perfectlv satisfied with the result.

—*Allgemeine Militär-Zeitung*, Darmstadt, No. 103, December 30, 1895.

War Materiel—United States.

Captain Jaques (late U. S. Navy, and of Bethlehem Iron Works) read a paper in the theater of the United Service Institution on Wednesday, November 13th last, covering so wide a field that much of it necessarily consisted of statements which we could do little more than repeat. We prefer to single out the special features and dwell on them.

The lecturer considered that the introduction of smokeless powder is at present telling more on gunnery than anything in gun construction, and he considered that England had been more successful with cordite than other powers with any other form of smokeless powder. In America the Leonard and Peyton powder has come in to some extent for the army, and the Maxim-Schupphaus, which only combines from 5 per cent. to 10 per cent. of nitro-glycerine with from 94 per cent. to 89 per cent. military gun-cotton, offers the advantage of a low temperature of combustion and probable saving of erosion of the gun lining. The grain is a cylindrical stick with seven or more horizontal holes which, burning from the inside, give an increased area of burning and increased formation of gas and pressure as the projectile moves up the bore. At present the U. S. Navy have such a fear of nitro-glycerine powders that it has probibited their use. The lecturer thought that erosion of bore might be diminished by cold rolling, and that something might be done by the use of alloys, such as nickel. He had a design of his own in which a few hollow press forged cold-drawn taper cylinders of alloyed steel were united by hydraulic power.

In armor-piercing projectiles Captain Jaques considers that the United States had taken the lead. In the Wheeler-Stirling projectiles he believed were combined uniformity, surety of production and perforating power, not so readily obtained by any other makers in the world. The present requirement for armor piercers in the United States is that they shall perforate, unbroken, an ordinary steel, oil-hardened, and annealed plate, of a thickness equal to a caliber and a quarter. As afterwards brought out in discussion by Mr. Hadfield, the English pass test is the perforation of a compound armor equal to a caliber and a half thick, but the projectile is allowed to break up if all the fragments pass through the plate. Wheeler-Stirling projectiles have perforated Harveyed armor plates uninjured. On November 2nd, 1894, a 6-inch shot weighing 100 lbs. perforated a 6-inch Harveyed plate uninjured, and a shot that has behaved in a similar way was presented by the lecturer to the United Service Institution. Last February 24th, a 12-inch shot perforated a 14-inch Harvey plate, at a velocity of 1858 foot-seconds, with no injury, beyond one inch being taken off the point. Generally it is now considered in America that 6-inch Harveyed plates can defeat 6-inch projectiles, including the excellent ones made by Holtzer, which may be taken as the standard for international comparison.

It appears probable that the projectile likely to be generally used on service is of a type called "semi-armor piercers," corresponding to English armor-piercing shell. They have small bursting charges, combined with a consid-

erable power of perforation, and may come in for quick-fire guns, because it will often be difficult in action to decide whether common shells or armor-piercing projectiles ought to be used, and so this compromise may be useful.

Passing to ordnance, the lecturer said that Great Britain and Russia alone had actually brought wire guns into the service. He considered that Woodbridge, Longridge and Schultz had about equal claims to the paternity of wire guns. The Brown gun is the best exponent of the system in America at present. In armor the United States have an enviable record. The Carnegie Company, the lecturer said, is taking the lead at present; the chief advances on the year are the gas-hardening methods of Krupp, Schneider, and the re-forging process, patented by Carnegie. The latter compresses and toughens the plates, and works down the crystallisation produced by the Harvey process. Excellent results obtained with thick Harveyed plates were mentioned, especially one on September 4th last, when a 14-inch plate for the *Iowa* resisted the attack of 10-inch and 12-inch projectiles so well that extra tests were tried. A Wheeler-Stirling shell, weighing 850 lbs. with 1800 foot-seconds velocity, broke up on the plate and cracked it, but did not perforate it. A Wheeler-Stirling 13-inch shell, weighing 1100 lbs., eventually perforated the plate, but caused no cracks. It struck with a velocity of 1800 foot-seconds, but this 14-inch plate had borne the test required for one 17 inches thick. It may be seen that when shot believed to be specially excellent are employed against plates claiming also special excellence, some other element of comparison is needed. Hadfield has made projectiles which have borne repeated firing against steel. We could wish that the projectile presented by the distinguished lecturer to the United Service Institution could be again fired against armor in this country. Perhaps this might be possible if duly arranged.

—*The Engineer*, November 22nd, 1895.

Armor Plate Making—England.

For thirty-three years Sheffield has enjoyed a practical monopoly of the armor-plate trade. That has now been challenged by the Clyde. Two first class men-of-war, the *Ramillies* and the *Terrible*, have just been constructed by Messrs. James and George Thompson, of the Clydebank Shipbuilding Yard, Glasgow. The plates for the *Ramillies* were made in Sheffield, but for the *Terrible* a Glasgow firm, Messrs. William Beardmore and Co., Parkhead Forge and Steel Rolling Mills, produced the casemate armor. This industry is a new departure on the Clyde, and is the first serious competition that Sheffield has had in the only heavy industry that remains of all those it once held exclusively in its possession. The history of armor plate is not so old as some people imagine. It dates no further back than 1860. At that time the French Admiralty had a ship named *La Gloire*, which was the cause of no little alarm to the British Government of the day. *La Gloire* was a 90-gun three-decker, built of wood. The French cut her down into a corvette, armed her with forty big guns, and, for the first time in naval history armored her with hammered iron plates 4½ inches thick, 5 feet long, and 2 feet wide. When the British Admiralty heard of this new thing in war vessels they stopped the construction of ten 90-gun and 100-gun timber-built ships, in order to follow the French example. Sir John—then Mr.—Brown, who was giving his attention at the time to railway material, happened to be returning from his usual autumnal visit to the Continent when, stopping at Toulon, the French ship put into the harbor. He asked to be allowed to go

on board, but permission was refused. He spent the rest of his time while the ship was there scrutinizing her through his glasses, the result being that he came to the conclusion that the plates could be rolled so as to produce armor much more trustworthy, tenacious, and uniform in quality. On coming back to Sheffield he devoted his energies in this direction, travelling up and down the country in search of machines adequate to his purpose, and eventually procuring what he required from Mr. Shanks, of Glasgow. In 1862 the Premier of England, Lord Palmerston, visited the Atlas Steel and Iron Works, where he found that the expectations of the Sheffield manufacturer had not been disappointed. Plates of various thicknesses and lengths were successfully rolled, and the Premier was convinced that the day of wooden men-of-war was past. The result was a second visit. This time the Lords of the Admiralty, headed by the Duke of Somerset, and accompanied by a staff of 100 officials, came to Sheffield to witness the opening of a new rolling mill which had been put down at the Atlas Works. A large number of plates, varying from 4½ inches to 12 inches thick and from 15 feet to 40 feet long, were rolled in their presence. From that day "hearts of oak" were superseded by hearts of iron. Up to 1863 the Atlas Works supplied plates which armored fully three-fourths of the whole British navy of the period. After that came the prolonged and stubbornly contested battle between plates and projectiles. Other manufacturers, of course, tried their hands at the new armor both in Germany and this country, but Brown's during that period kept the lead. In this great specialty of the iron industry, however, there was no such word as finality. Wood gave place to iron, and iron in time was superseded by compound armor—that is, plates with an iron backing and a steel face. For many years compound armor, designated as the "Ellis" and "Wilson," the first being made at the Atlas and the second at the Cyclops Works, held their pride of place. Compound armor has now come to an end, and the ships' clothing of to-day is, as the survival of the fittest, of steel, with the face "Harveyized," a process named after its discoverer. Now Sheffield finds Glasgow a rival for the industry which has brought to the city so much work and given to its people so much wages.

Of all the enterprises in which Sir John Brown excelled—and these included the first conical steel buffer ever put upon a railway, as well as the introduction of the iron trade to South Yorkshire, he will be best remembered by the result of his memorable visit to the Continent in 1860, which led to the revolutionizing of all the navies of the world. It dissipated the fear of certain patriotic landowners that the day would come when there would not be enough British oaks to build British men-of-war. One of them set himself industriously to plant forests of oaks wherever he had suitable land, in order that there might be at least one place from which the Government could draw timber to build British craft of other days. That, as we have said, is now all ended, and the nations of the earth have long since given themselves over to armor-clads. In Sheffield there are three firms who make a specialty of these immense plates—Messrs. John Brown and Co., Messrs. Charles Cammell and Co., and Messrs. Vickers, Sons, and Co. The evolution of armor has been so rapid that immense masses are manipulated with the utmost care under forging presses, which exert a pressure of from 4000 to 6000 tons, and another is in course of construction equal to 10,000 tons. The 4½ inch plates, which were considered a marvel in 1860, have been excelled by armor 24 inches thick. These, of course, were of iron. No British ship has had clothing so thick as that, nor have any, indeed, been supplied for ships for foreign

powers. Italy has had two warships, the *Duilio* and the *Dandolo*, coated with plates 22 inches thick, and the *Inflexible* was partly clothed with armor of similar dimensions. The maximum thickness of plates used for battleships now in course of construction is 18 inches of steel Harveyized. This is regarded as affording more resisting power than the 24-inch of the old type. It can scarcely be considered surprising that Sheffield should now find a rival near its throne in this great specialty. The very fact that warships were built on the Clyde with the great steel industry close at hand, must have suggested to many minds the thought that the armor might be produced there as well. In all men-of-war built at Glasgow the production of the armor at home —if the Clyde firm can undertake the heavy armor as well as the other—will save one great item of cost—that of carriage. It is not likely, of course, that the firm which starts with casemate plates will be content to stop there, and Sheffield will therefore have to make up its mind to the development of the armor plate trade in the north. The marvel is that the business should not have been attempted there before. Of course, there were obstacles in the way. Chief among these were the enormous expenditure, the necessity of extended experience, such as years alone can give, and the uncertainty of continuous work. Although the three Sheffield firms are now well employed in producing plates for the British Government and other powers, they have not always been so fortunate. Protracted periods of inaction have, as the saying is, "taken the gilt off the gingerbread," and for many many months even for a year or two at a time, costly plant and skilled staffs have been equally idle. The hope and expectation are that increasing requirements at home and abroad may be equal to the development of output, particularly when, as at Glasgow, other centers of industry turn their attention to what has been for so long a period exclusively a Sheffield business.

—*The Engineer*, October 4, 1895.

Tests of Creusot Armor Plates.

In April last the Royal Navy Department of Sweden awarded a contract for armor plates to Messrs Schneider & Co., of Creusot. The plates are intended for the new vessel, the *Oden*. The one that was recently tested was 2 meters (6.56 ft.) long by 1 meter wide (3.28 ft.), with a thickness of 0.25 meter (9.84 in.). According to the terms of the contract, it was called upon to sustain three shots from a gun having a caliber of 15 centimeters (5.9 in.) throwing a chrome steel projectile forged at Finspong, and meeting the requirements of the Swedish Navy; the same to weigh 99 lbs., and to have a velocity at the point of impact of 1,850 ft. per second. Under these conditions no portion of the shot or the plate was to be forced through the target; the first shot was to produce no cracks, and the other shots must detach no pieces that would leave the crew exposed. The three shots were fired into the apices of an equilateral triangle having sides equal to about 3½ calibers and 4.8 ft. from the side, located in the center of the plate, the base being horizontal. None of the three shots produced any crack in the plate, each one having rebounded to from 14 ft. to 18 ft. After the trial the plate was removed from the target to which it had been fastened by 12 bolts, and only a slight bulging and crack was visible at the back. The plates thus greatly exceeded the specifications, and the shot which suffered only a very slight distortion evidenced the excellent quality of the work done on projectiles at Finspong.

—*The American Engineer*, October, 1895, from *Le Yacht*.

Test of Holtzer Projectiles.

A test of Holtzer armor-piercing projectiles, manufacured by the Midvale Steel Company, was made at Sandy Hook on September 19. Four of the projectiles were fired at an 11½ in. nickel steel armor plate, and in each case the projectile passed cleanly through the plate, then through 3 ft. of oak backing, and penetrated for a considerable distance into the sand butt. The projectiles were then dug out and found to be in perfect condition. Each shell weighed 57 lbs., and was fired so that it struck the plate at a velocity of 1,620 ft. per second.

—*The American Engineer*, October, 1895.

Test of Armor Plate for the Iowa.

On September 17 the final test of the armor plate for the United States battleship *Iowa* was held at Indian Head. The target was 18 ft. long, 7 ft. 6 in. high, and 6 ft. 6 in. deep. The face was a 14-in. double forged steel plate backed by 5 in. of oak, and fastened by bolts to the framing. In the previous tests two shots had been fired at this plate from the 10-in. gun and one from the 12-in. gun without injuring the framing in the least, while the plate itself more than exceeded requirements, although penetrated and slightly cracked by the shot from the larger gun. The last test was for the purpose of ascertaining what damage would result to the framing of a ship if her armor were pierced by a projectile, and a 13-in. gun was therefore used. The shot weighed 1,000 lbs, and a velocity of 1,800 ft. per second was given by a charge of 480 lbs. of brown powder. Only one shot was fired, and that passed through the plate, backing, etc., and, striking some object, was deflected and lost in the woods back of the target. The plate exceeded expectations, two cracks, in addition to the hole made by the shell, being the extent of the damage. As for the framing, the only question was whether the damage would be local, confined to that portion through which the projectile passed, or whether the entire structure would be demolished, the rivets pulled out, and the bulkheads buckled. Three divisions through which the shell tore its way were crumpled like paper, and were partly carried away with the projectile, but the remainder of the framing was unharmed and not a rivet started. This experimeut is, we believe, the first that has been made with the framing of modern war vessels, and seems to have demonstrated that it is as strong as the armor, as that used was an exact duplication of the side section of the *Iowa*.

—*The American Engineer*, October, 1895.

c. Powder and Explosives.

Determination of the Temperature of Explosion.

In a paper published on the Continent, and entitled *Recueil des Travaux Chimiques des Pays-Bas*, *par*—and then follows the list of its distinguished compilers—we find some interesting references to the method of determining the temperature of explosion of explosive substances in general, and in particular of the boiling point of nitroglycerin, by *M.* C. A. Lobry de Bruyn, of the *Laboratoire de la Marine*, Amsterdam. He states that in various treatises on explosives, M. Champion is mentioned as having placed the boiling point of nitroglycerin at 185°. The method used by him, and also others, is not considered by M. Champion to be sufficiently reliable. It consists in taking a bar of copper, warmed at one end, and containing holes at various intervals

along its length filled with a fluid, in which is immersed in each case a thermometer. As soon as a proper equilibrium of temperature is established along the bar, the readings of the thermometers form the points of a curve, thus rendering it possible to determine the temperature between the holes graphically. Pieces of explosive would then be placed at intervals along the bar, and the action of the various degrees of heat on them noted. The author expresses himself doubtful as to whether explosives would actually acquire the temperature of the bar at the points where they were placed, and in support of this view he quotes the fact that results obtained on this system give much higher temperature determinations than are ordinarily admitted, and than are obtained by warming explosives in thick test-tubes placed in a bath of oil. By means of the copper bar M. Champion, working with M. Leygue, gave the temperature of explosion of nitroglycerine as 257°, and for that of guncotton 220°, although it was impossible to warm either of these explosives beyond 190° without explosion. By this oil-bath process the readings vary slightly, according to the rapidity with which the bath may be heated. We may mention here that M. Guttmann, in his "Manufacture of Explosives," explains the discrepancy between MM. Leygue's and Champion's results with those of other experimentalists on the supposition that these two gentlemen used extremely small quantities of explosive in their experiments, and stated it as a fact that the larger amounts cannot be heated without explosion above 180° C. In continuation of his criticisms of M. Champion, M. de Bruyn quotes this gentleman where he refers to the pressure of the gases evolved by nitroglycerine as determined by M. Lorm. These are given 5 mms. at 15° C., 27 mms. at 87°, 30 mms. at 100°. In the case where the boiling point of nitroglycerine should be situated below 200°, it would be well, if it were possible, to distil the nitroglycerine under a reduced pressure. It is generally known that the boiling point of water is lowered by diminishing the pressure on it below that of the atmosphere, and the author has proved a parallel case by distilling hydroxylamine, a substance never found in the free state, and one the detonating point of which is situated at about 130°, without any danger at a pressure of 20-40 mms., representing a boiling temperature for this substance ranging from 60° to 70°. And yet hydroxylamine is a less stable substance than nitroglycerin. The latter substance, as also guncotton, in a perfectly pure state may be warmed for a prolonged period at a temperature of 100° without any serious degree of decomposition; while, on the other hand, hydroxylamine at a temperature of 70° or 80°, applied under the normal atmospheric pressure, practically explodes instantaneously. The author experimented in the ordinary way, though taking special precautions to provide against danger in case of any sudden action on the part of the substances under examination. Nitroglycerin, suitably protected, was warmed in a bath up to 160°, the pressure being about 15 mms. No extraordinary boiling phenomena were observed, although volatilization of the nitroglycerin was well marked, spots of it condensing little by little on the sides of the glass. It is the author's opinion that with a mercury column to regulate the pressure, it would be possible to distil nirtoglycerin. The negative result of these experiments in the eye of the author is to establish that at ordinary pressures the boiling point of nitroglycerin is not higher than 185°. The author questions whether M. Champion meant boiling, so called; he speaks in his work rather of a giving off of yellow fumes. It appears, therefore, to be a question of the rapid discharge of gaseous products of decomposition, which (as with hydroxylamine) precede detonation. The author draws attention to

the fact that his trials do not accord with several of those of M. Lorm, and he suggests that the development of nitrous fumes may have something to do with it.

—*Arms and Explosives*, December, 1895.

d. Torpedoes.

Test of a Large Howell Torpedo.

Commodore Sampson, Chief of the Ordnance Department, United States Navy, witnessed at Tiverton, R. I., lately a test of the large Howell Torpedo, which the Hotchkiss Company of Providence, R. I., have been developing for the past few years in France and this country. This is really the first official trial of this size of the Howell make, which is 17.72 inches in diameter, the same as the Whitehead adopted by the United States Navy, while the Howells now in service are but 14 inches. The torpedo was fired three times in succession at a target 600 yards distant, and showed excellent direction and an immersion of 4½ feet, while it ran 500 yards further before broaching and with great regularity, the runs varying but three seconds. Only between 27 and 28 knots were secured, one knot short of the expected speed. The sluggish running was plainly due to the coldness of the water and inability to warm up the oil on the running parts at the testing station, as would be possible on shipboard. It is claimed that torpedoes depending on chemical heat for motive power would be even more greatly handicapped. As high as 30 knots have been secured from this torpedo, and for short runs 32 knots are expected. The torpedo tried is approximately the same size and weight as the Whitehead adopted by the United States Navy, but carries about double the explosive charge—200 pounds of guncotton.

This new torpedo is driven by highly spun fly wheels, there being a double equipment instead of a single, as in the 14-inch, and a new tube has been designed for its discharge, the side expansion tube having been abandoned for the direct powder discharge from the breech block. Steam is at present used for driving the engine in giving the fly wheel its power, but shortly compressed air is expected to be used with more favorable results. The advantage claimed for this particular torpedo over others, is its large charge and speed for its comparatively small weight and size.

—*The Iron Age*, December 19, 1895.

The Howell Automobile Torpedo.

An interesting lecture on the Howell Torpedo was delivered recently by Mr. J. E. Wilson, an official of the Torpedo Works of the Hotchkiss Ordnance Co., at Providence, U. S. A., before the Providence Association of Mechanical Engineers; and as the inner workings of this clever piece of mechanism are not perhaps so well known as its merits seem to deserve, we take pleasure in reproducing some of Mr. Wilson's remarks.

It appears that the Howell Automatic Torpedo takes its name from the inventor, an American naval officer, Comm. J. A. Howell, who holds the position of Commandant of the Washington Navy Yard.

His invention consisted in applying the principles of the gyroscope to the moving topedo by means of a heavy fly-wheel, into which was to be stored sufficient energy—by imparting to it a high rotary velocity—to actuate all its moving mechanism, and still more than that, as will be seen, to the full accomplishment of its mission. The high velocity of the fly-wheel develops a gyroscopic influence which is at once the vitality potent and most remarkable

result of the combination. In mechanics there has not been much occasion to become acquainted with the forces of gyroscopic action, except at moderate speeds; but when a wheel like this, weighing 130 pounds or more, and about 14 inches in diameter, is revolved at the rate of 10,000 revolutions per minute, certain manifestations out of the ordinary are to be found.

The fly-wheel is the heaviest single piece of the torpedo, weighing in the smallest size 130 pounds, and when spun up to 10,000 revolutions per minute it offers very considerable resistance to any effort to divert it suddenly from its plane of rotation, if it is free to turn or roll transversely to this plane. The entire weight of the torpedo is only 516 pounds; its diameter a little over 14 inches; its length about 11 feet; and as it is made up of a very light bronze shell, and is immersed in action in an unstable medium which presents very little resistance to vibration, the value of this law, as utilized to hold the weapon from horizontal deflection upon its course, is of the utmost importance, assuming that the plane of rotation shall be maintained truly vertical. In order to ensure this, other devices are employed, which will be described lower down.

The fly-wheel is forged of the toughest Midvale steel, with a web about 1 inch thick, and a rim 6½ inches wide, with a crowning periphery averaging about 1½ inch thick. It is mounted upon an unannealed tool-steel shaft, and carries a steel bevel gear on each side. The boxes or bearings in which the shaft runs are also made of the same grade of steel, and provided with anti-frictional rolls and balls. All are fitted with the greatest nicety, not over two ten-thousandths of an inch error being allowed. The accuracy attained may be judged from the fact that it requires ninety minutes for a wheel to come to a state of rest after having its full speed of 10,000 revolutions per minute.

The greatest care is necessary throughout all operations in producing the wheel. The steel must have a high elastic limit and far in excess of the strain brought upon it by the centrifugal force generated. The density must also be as evenly distributed as possible, to avoid distortion and lack of balance.

Should the metal lack uniformity or even distribution of density throughout its mass, higher speeds, with the resulting severe strains, develop vibrations which are hard to cope with. These vibrations may be excessive at 7000 revolutions, entirely disappear at 8000, recur again at 9000, and again be quiet at 10,000. The only means of dealing with these troubles lies in perfecting, as far as possible, the methods of manufacture.

The propellers are each three bladed, one right hand, the other left hand, as they revolve in opposite directions. The shank of each blade is screwed into the hub, and is free to turn in the thread. As the fit of this screw is of the utmost importance, it may be said that no part of the torpedo has greater care and exactness imparted to it than the propellers.

During the run of the torpedo it is desirable to maintain as even a rate of speed as possible. Manifestly if the blades were fixed at a permanent pitch the speed of the torpedo would retard in proportion as the energy of the wheel is given out. Hence, provision is made gradually to increase the pitch of the blades throughout the run. The device for accomplishing this may appear somewhat complicated from a worded description, but is really simple enough. The shank of each blade is provided with a lever carrying on its end an anti-friction roller, which is guided by a groove in a three sided block,

which slides on the shaft ahead of the propellers. Forks move these blocks; the fork stems being carried by a cross-bar or frame lying just above a scroll cam plate or face cam, with a roller and stud fixed to the under side of the frame and fitting into a groove of the cam. This cam is revolved by a train of gearing, actuated by a worm on one of the shafts. The worm rides loosely on the shaft, having clutch teeth on one end. An antagonizing clutch fixed to the shaft transmits the motion to the train. The free worm, with its clutch, is made to slide into contact with the fixed clutch at the moment the torpedo strikes the water, by means of a trigger, which holds the worm clear of the fixed clutch until the moment when the rush of water against its outer end causes it to pass over a spring designed to hold it in either position against considerable pressure. From the time that the torpedo is immersed, the pitch of the propeller blades is thus constantly increasing up to the calculated time required to make the effective run. This time being expired, the pitch-frame stud roller has reached that position in the cam groove where the groove is concentric, so that the cam may continue to revolve and no further change of pitch can occur until it is set back again for another run.

What the brain and conscience are to the human mechanism, so are the devices, about to be described, to the torpedo. They relate to means for ensuring that the torpedo shall follow a certain predetermined course without deviation horizontally or vertically therefrom. Manifestly the torpedo may meet with many influences which cannot be forseen, except in the general way, but there are others that can. It must recover from its initial dive. There are currents and tides, and possibly other more or less yielding obstructions, in its path, possibly permanent rudders, due to lack of perfect contour of the shell, all tending to divert it from the path of strict rectitude; but the machine itself takes notice of them and corrects the errors, as it goes along, within certain limits.

Immediately abaft the fly-wheel are arranged the regulating and impulse mechanisms, all contained within rings which support the moving parts, and also the propeller shafts and tiller rods. Each shaft carries a worm leading into the gears of a transverse horizontal shaft. Midway of this shaft are two eccentrics with rods, connected at their forward ends with steel racks, having a series of notches on the opposing ends. The eccentrics being set opposite each other impart a reciprocating movement to the racks, causing them respectively to approach and recede from each other simultaneously. Alongside of the racks—called impulse racks—and arranged to slide with them at certain times, are bars, one above the other, the after ends of which are connected with the tiller rods passing aft through stuffing boxes in the tail bulk-head and there connect, one with the horizontal and one with the vertical rudder posts. About the longitudinal centers of these bars are studs which serve as pivots for pallets. The pallets are about four inches in length and swing on the studs like a tilting board, their ends projecting between and in the path of the impulse racks. It is obvious that should one of the racks engage with the free end of a pallet, it, with its bar and tiller rod, would be carried with the rack, thus imparting to the rudder an impulse; it might be in one direction or the other, according to which end of the pallet was engaged. Again, should the pallet have sufficient tilt to cause it to engage with an early step of the rack, the sliding movement would be greater than if with less tilt it engaged a later step and *vice versâ*.

The tilt or angularity of the pallets is determined automatically by a delicate

cate system of levers partly controlled by pendulums, nicely hung in the main frame and guided anti-frictionally, so that no derangement can take place.

Following the operation of the pendulum mechanism which controls the horizontal rudder, should the torpedo incline nose downwards, the pendulum swings forward, one end of the pallet engages with the rack, in the step which is presented by the degree of incline, and carried by the rack to the end of its stroke, giving an up-rudder impulse; the pallet, bar, tiller rod and rudder returning to the center by means of springs; and these impulses continue until the torpedo is righted. The reverse is the case, of course, if the torpedo is inclined nose up. When the torpedo is level, the pallet escapes contact with either of the racks. The horizontal rudder is situated away aft, and is larger, superficially, than the vertical rudders—thus it is in a true sense a steering rudder so far as vertical work is concerned.

In this description the effect of the immersion mechanism, which, with the pendulum, acts upon the horizontal rudder also, has so far been neglected.

The vertical or rolling rudders, although actuated practically in a way similar to the horizontal, viz., by means of pendulum, pallet, bar and tiller rod, are not, in a full sense, steering rudders, and this is one of the most interesting peculiarities of the machine.

In speaking of the gyroscopic influence of the fly-wheel, it was stated that its resistance to deflection was very great, if it was permitted to roll transversely to its plane of rotation. And, on the other hand, if the wheel is made to roll in this direction, thus changing its plane of rotation, its effect upon the torpedo would be to carry it off to the right or left, as the case might be. Consequently all that is required to preserve the straight horizontal course is that the torpedo should be kept on even keel. To take the case where it has rolled; the impulses of the vertical rudders tend to deflect sidewise the tail of the torpedo by a series of sudden jerks. The effect upon the fly-wheel is immediately felt and answered by a righting up of its rotative plane to the true vertical, at which point the pendulum reaches its neutral position and ceases further to operate the gear.

On one side, opposite the impulse mechanism, is a perforation over which is placed a flexible diaphragm, and this yields to the external pressure due to the depth of immersion for the run of the torpedo. It is called the piston. The movement thus secured is resisted by a spring, weighted proportionately with the entire movement of the piston and the extremes of depth desired. The piston is made to act upon a guide for the horizontal pallet, independently of its control by the pendulum. This is necessary because of the buoyancy of the torpedo, constantly urging it to rise to surface.

The weapon is made in four sections, known as the after-section, containing the machinery; the mid-section, containing the fly-wheel; the charge sections, of which there are two, one for practice and one for service. The practice head is filled with water to the exact weight of the war head when charged with its 100 pounds of guncotton. The firing pin, carried by the war head, is made to be safe from action until it has run some distance through the water. It carries a safety nut with four blades similar to a propeller. This is threaded loosely on the firing pin, and its position at the commencement of the run is against the nose, so that the thread would have to be stripped before the pin could act. In passing through the water the blades cause it to run forward and oft the thread, so that a blow against the pin or any of the blades of the nut would cause it to act.

In its active or war condition, the war head carries its charge of guncotton, cut into blocks, packed closely, and surrounding a thin case of cotton which is absolutely dry, the main charge being saturated with water up to the exact limit of weight prescribed.

Throughout its construction the greatest care is necessary as to the weight of its parts, and the location of the heavier portions within the body, to ensure that the centers of gravity and buoyancy are at proper points, that all mechanism shall operate free from undue friction or vibration, and withal that the parts shall be as light as possible to permit the use of the largest available charge of explosive, and yet of sufficient strength to endure numberless practice runs for drilling purposes and maintaining the entire stock on board ship in perfect adjustment and running order.

The launching apparatus (or tubes, as they are called) assume several forms, according to their position on board ship. For instance, that in the bow is fixed, and the aim of it is directed by the officer at the wheel. The deck tube is designated as central pivot, in that it swings on a pivot near its center, the recoil being taken on a circular deck plate, clamped thereto before firing. The between deck or broadside type also swings horizontally, but its pivot is near the muzzle, the weight of the breech being taken by a carriage travelling either on an overhead rail or deck plate, as may be desirable. Suitable train gearing, meshing into a circular rack, is provided, thereby requiring only the power of one man—the gunner—to train and discharge the torpedo.

The tubes are of cast bronze, averaging about twelve feet in length, bored to size, allowing but a few hundredths of an inch error. Grooves are cut longitudinally in the bore, one on each side, a little above the center of the diameter, for the trunnions of the torpedo to travel in.

A door at the breech admits the placing of the torpedo within the tube, after which the door is closed and secured by a steel yoke. On the right and midway of the length of the tube, is placed a motor, a very interesting steam turbine, provided with a steel shaft made to slide lengthwise and controlled by a cam plate at the pleasure of the operator. The inner end of this shaft carries a clutch working in opposition to the intermediary clutch of the torpedo, which has been described. The motor is provided with a tachometer, by which the speed of the revolution may be observed.

Forward of the motor is placed the stop pin, the office of which is to indicate the position of the torpedo when slid into the tube, the trunnion of it having a notch into which the end of this pin fits, thus securing the torpedo from sliding out until the moment of firing, and especially fixing it in position where the alignment of the fly-wheel and motor shafts are coincident.

Around the breech end of the tube is placed a ring called the entrance ring, which is a cored casting covering ports or holes through the tube casting. Leading from this entrance ring is a pipe about three inches in diameter, running forward on the port side of the main tube and passing into a casting similar to the upper half of the entrance ring, called the firing pipe connection. Leading back from this connection is another pipe on the starboard side of the main tube, and terminating near the breech in the breech block. Thus is established an opening or passage through the breech block, the starboard firing pipe connection, the port pipe, the entrance ring, and through the ports into the tube.

The breech block contains the exploding mechanism. Its cover lifts by depressing a spring catch, permitting the insertion of a metallic cartridge

containing about six ounces of cubical powder. The closing of the cover leaves the hammer cocked. Running alongside of the tube, directly under the starboard firing pipe, and supported by brackets, is the firing rod, with its attachments so timed that its offices are performed in proper sequence. This rod is actuated by a lever depending therefrom, and may be briefly described thus:

The torpedo being in place, the motor is clutched with the fly-wheel shaft, the cartridge inserted, etc., steam admitted, and everything is ready for a shot. The gunner simply pushes forward the firing lever, which first closes the throttle valve; second, withdraws the motor clutch; third, withdraws the stop pin; and fourth, trips the hammer.

The pressure behind the torpedo is only about 14 pounds per square inch, causing it to clear itself from the tube, when it dives at an angle approaching 30 degrees. The depth it reaches varies according to the amount of the powder charge and angle of depression of the tube, when, owing to the operation of the mechanism described, it rights itself to the depth to which it is set, when it maintains its horizontal plane, within reasonable limits.

All practice shots are made with the intention of recovering the torpedo. In order to make sure of this, it carries a tube about $6 \times 2\frac{1}{2}$ inches, of phosphide of calcium, placed in a pocket in the upper surface of the mid-section. The entrance of water to this chemical generates a gas which flashes into flame when coming to the surface, thus exposing its locality. In its war condition the phosphide is not used, and provision is made for a leakage in the head, which is so slight as not to affect it during its run, but sufficient with time to overcome whatever buoyancy it may have, causing it to sink at the end of its run, and rendering the explosive innocuous. All this, of course, is in case it misses its mark.

—*Arms and Explosives*, December, 1895.

e. Range and Position Finders.

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f. Miscellaneous.

Influence of Carbon on Iron.

The first paper, on "The Influence of Carbon on Iron," by Mr. John Oliver Arnold, F.C.S., embodied the results of researches undertaken by the author primarily to determine whether, at high temperatures, the carbon still remained in combination with the iron. A series of eight 3-inch square crucible steel ingots, ranging in carbon between 0.08 per cent. and 1.47 per cent., the total impurities other than carbon averaging 0.2 per cent., were hammered and rolled to $1\frac{1}{16}$ inch in diameter. They were then submitted to chemical, mechanical, microscopical, thermal, and magnetic tests, in three standard physical conditions, namely, normal, or cooled in air; annealed, or very slowly cooled; and hardened, or very rapidly cooled.

The differential analyses for carbon confirmed the conclusion arrived at by the author in a previous research, that the hard plates of Sorby's laminæ consisted of pure crystallized Fe_3C, and under certain conditions contained practically the whole of the carbon present in the steel.

The mechanical tests showed that in normal steels the tenacity increased with the carbon up to 1.2 per cent.; a further addition of carbon causing a diminution in the stress. Thus the tenacity of ingot-iron containing about 0.1 per cent. of carbon was found to approximate 21 tons per square inch, the

maximum stress sustained by iron containing 1.2 per cent. being nearly 62 tons per square inch, whilst the stress registered at 1.5 per cent. fell back to about 56 tons. In the case of thoroughly annealed steels the stresses were distinctly less than those obtained from the corresponding normal metals, the maximum tonnage being registered at about 0.9 per cent. of carbon. With higher carbons the strain rapidly diminished; being at 1.5 per cent. of carbon only about 22 tons. The ductility of normal steel diminished with the carbon; the elongation with 0.1 per cent. of carbon being 47 per cent., and at 1.5 per cent., 3 per cent. on 2 inches. The ductility of the corresponding annealed metals was slightly greater up to 0.65 per cent., but between 0.65 per cent. and 1.2 per cent. it was less than that obtained from the normal steels, registering a minimum at about 0.9 per cent. Under compression the softness of normal steel decreased with the carbon until 0.9 per cent. of that element was present; between 0.9 and 1.5 per cent. the flow was practically stationary. Annealed steels under compression indicated a maximum hardness at 0.9 per cent., and were distinctly softer than the normal metals. Between 0.9 per cent. and 1.5 per cent. the steel became remarkably soft under compression; steel with 1.5 per cent. of carbon was softer than iron containing 0.1 per cent. In hardened steels the rigidity of the metals increased enormously as the carbon rose, and between 0.9 per cent. and 1.5 per cent. the metal was practically incapable of flow under compression. The remarkable mechanical tests obtained from the annealed steels between 0.9 per cent. and 1.5 per cent. were undoubtedly due to the decomposition of Fe_3C into free iron and graphite.

The microscopical investigation showed that pure iron consisted of cubic and octahedral crystals. On the introduction of carbon a new constituent, which became dark brown on etching, appeared and remained sharply localized in the iron, until at about 0.9 per cent. the whole mass consisted of this constituent. This point was defined as the saturation point of steel. Steels containing less than 0.9 per cent. of carbon, and consequently free iron, were termed unsaturated, whilst steels containing above 0.9 per cent. were distinguished as supersaturated, because they contained an excess of Fe_3C. The particular method necessary to obtain reliable sections of hardened steel was described. The general results of the microscopical examination sustained the theory that the hardness of quenched steel was due not to a hard allotropic modification of iron, but to a definite sub-carbide corresponding to the formula $Fe_{24}C$. This formula involved a maximum evolution of heat of combination, and a maximum absorption of heat of dissociation respectively, on cooling and heating, in iron containing about 0.9 per cent. of carbon. Determinations of these heats *in vacuo* gave decisive maxima both on heating and cooling at 0.89 per cent. of carbon.

The magnetic observations on hardened steels had led the author to the conclusions that (1) the magnetic permeability varied inversely as the carbon present; (2) the permanent magnetism was directly proportional to the carbides of iron present: and (3) in iron containing between 0.1 per cent. and 0.9 per cent. of carbon the permanent magnetism was directly proportional to the sub-carbide of iron present.

The author based the existence of a sub-carbide of iron, possessing the formula $Fe_{24}C$, to which the phenomena of hardening and tempering were due, on the following experimental facts: (1) the well marked saturation

points in the micro-structure of normal, annealed and hardened steels; (2) a sharp maximum in a curve, the co-ordinates of which were heat evolved or absorbed at the carbon change point, Ar. 1, and the carbon percentage; (3) a point in the compression curve of hardened steels at which molecular flow ceased; and (4) a sharp maximum in a curve, the co-ordinates of which were the carbon percentage and permanent magnetism in hardened steels.
—*Engineering*, December 13, 1895.

D. FORTIFICATION.

Rapid and persistent has been the effect of the constant references to the imperfections and weaknesses of our obsolete fortifications, called forth, as they were, by the great revolution which has taken place in the entire domain of strategy; confidence in them was soon lost, it seemed impossible to overcome the difficulties in the way, fortifications apparently lost their value and appeared to the strategist to have become harmful rather than useful, inasmuch as they tended to limit his freedom of action. Therefore, away with fortifications! was the cry. Scheibert is still discussing the question with Boguslawski. The Russian Buinizki has summed up and practically decided the matter for the present, in the following words: "The question of having fortifications or not is not an engineering question at all, but a purely strategic one, and has nothing to do with the condition of a fortification or its artillery. As long as strategy continues to secure the success of operations by holding on to certain points in the territory—and this will probably always be the case —just so long will the troops forced to hold these points protect themselves, certainly by temporary, and probably even by permanent fortifications; and if we do not expect from these fortifications more than we have a right to expect, their utility will more than counterbalance the outlay in erecting them."

But the question at once arises: "*What is to be expected of fortifications? What is their sphere of action, their purpose, the limit of their effectiveness?*" Two articles on land defense discuss this question. The author of the first, R. V., draws his conclusions solely from the war of 1870–71, as the only reliable way (a very doubtful mode of procedure), and decides that only such fortifications are of value as are capable, by their offensive power, of detaining the enemy who may be pressing into the country, or of injuring him. The principle of greatest possible concentration of the available forces is quite as true for fortifications as for the army in the field, in the sense that fortification armies of from 150,000 to 200,000 men be concentrated in large fortified camps—what for? "Not in the piling up of dead masonry, senseless combinations of lines and angles, etc., is to be found the value of a fortification, but in their offensive power and their effect on the attack that may be taking place"—but "a fortification war that makes no demand on the maneuvering capacity of the troops permits of the use of comparatively poor men, who would be of little use in the open field."

Toilow arrives at quite the opposite view deductively. He proposes to fortify those points in the theater of war, the possession of which will be under all circumstances of great importance for the operations of the army in the field, and the occupation of which by an adequate force will relieve the commander-in-chief of a care, a responsibility, and allow him greater freedom of action. A fortification derives its value from the section which it commands and which it secures for the army in the field. Its sphere of action is,

however, limited by its field of fire. The *offensive* pertains to the field army, not to the fortification garrison, therefore, the latter should be kept at a minimum. A fortification that, like Langres, can prevent an army from passing it on either side only by a far-reaching offensive movement, is falsely located. Just as the strong sections of a theater of war will probably never lose their value, so also those points in these sections, which, as natural thoroughfares, comprise the greatest number of communications, have any value for the army, and only such ought to be fortified.

"*Are fortifications to be constructed in permanent form* (*hence, in time of peace*) *or can they be replaced by field or temporary works?*"—Lieutenant-Colonel Leithner (Austrian army) says *No*, decidedly, to the second of the above questions, "because in the present age of greater preparedness and increased rapidity of movement in all the operations the time required for that purpose would probably be wanting, and that much more than was formerly the case; moreover, since even permanent fortification cannot keep pace (in resisting power) with the effect of modern artillery fire, this must be much more the case with field or temporary works." The arguments of Buinizki support this view. Since all other cover (such as wood, iron rails, etc.) cannot withstand the effects of vertical fire with high explosives, he requires even temporary works to be provided with concrete protection, and concludes that it will require the work of a thousand men daily for three months to prepare an infantry point of support for defense. He brings out the point in his discussion that the different systems of fortification determine their cost and the strength of the garrisons required, and *vice versa*, the latter determine the systems of fortification. The conclusion "temporary fortifications require half as many troops again or even twice as many, and field fortifications four times as many, as permanent fortifications for the same extent of front," is but the expression of a well-known principle in the art of fortification, but it is nevertheless well to recall it, on account of the requirement that we should draw away from the strength of the field army as little as possible for the occupation of the fortified points.

Toilow energetically objects to the idea of such fortifications "the projects for which, elaborated in great detail, sleep quietly in the archives awaiting their resurrection," for, in actual war these works, probably hardly begun, will have to be abandoned and allowed to fall into the enemy's hands, and with them many important points, or else we will be compelled to banish the army in them." Like so many other *preparations* in war, fortifications are nothing but the transformation of comparatively light labor extended over a long time (in time of peace) into a great and useful effect for a brief interval (in time of war), which effect could never, however, be otherwise attained at the moment when the crisis arrives." Conformably to this idea, the "proposed fortifications" which he admits under certain circumstances are not merely proposed on paper, but are partially constructed, a skeleton of permanent works being built at the most important points, so that the work required in time of war will be merely that necessary to fill out the intervals between these works already prepared.

—*Von Löbell's Jahresberichte* for 1894. 1895.

E. WAR SHIPS AND TORPEDO BOATS.

New Gunboats—United States.

The *Nashville* and the *Wilmington* have been recently launched at the yards of the Newport News Shipbuilding Company. The *Nashville* is a light

draft twin-screw gunboat designed for the usual duties of cruising naval vessels. In coast work her moderate draft of water will enable her to enter many ports from which most men-of-war are excluded on account of their greater draft. She is 220 feet long on the water-line with 38 feet beam. At her normal draft of 11 feet her displacement is 1,371 tons. She is schooner-rigged, with two smoke-stacks, and her total coal-bunker capacity is 390 tons. She has two types of boilers, cylindrical and water-tubular. She will be able to cruise without recoaling for long periods at moderate speed, using her cylindrical boilers only, being able rapidly to increase her speed to its extreme limit by starting fires under her remaining boilers. No attempt has been made to secure over 14 or 15 knots an hour, that being sufficient for the duties required of such a vessel. The engines driving the twin screws are of the quadruple-expansion type, so designed that the low-pressure cylinder can be disconnected when the vessel is cruising under ordinary circumstances. When running at full speed the high-pressure cylinders receive steam from the Yarrow boilers directly, while the two cylindrical boilers supply steam to the receivers between the high and first intermediate cylinders. At moderate speed, the low-pressure cylinders being disconnected, steam can be supplied to the two triple-expansion engines so formed by either of the batteries of boilers. The main battery consists of eight 4-inch breech-loading rapid-fire guns, four of them being on the upper deck; two 1-pounder rapid-fire guns and two Gatling guns. One fixed torpedo tube is mounted in the bow, and a searchlight is placed just above the pilot-house and forward of the foremast.

The *Wilmington* has been built for entirely different service. Although in every respect a perfectly safe seagoing vessel, the *Wilmington* and her sister ship, the *Helena*, whose launch will not take place for several weeks, are designed especially for river service. In external appearance the *Wilmington* resembles a small battleship, having a large military mast with two military tops, similar in all respects to the one on the battleship *Iowa*, which serves to command the banks of a river or houses in a town where she may have to prevent rioting. A conning tower on the mast, just below the first military top, enables the ship to be maneuvered at a height of 45 feet above the water line. The space available for quarters is large, and affords berthing capacity for many additional men besides her crew. To facilitate landing a large body of men she has boats of unusual size, her steam cutter and sailing launch being each 33 feet in length, or as long as those supplied to the heaviest battleships. The machinery consists of triple expansion twin-screw engines. The total coal-bunker capacity is about 280 tons. Two rudders are provided one ahead of the other, so arranged that it may be possible to run the vessel into a bank and let her swing around with the current when turning in narrow channels. Her battery is the same as that of the *Nashville*, and she has a searchlight on her military mast, but no torpedo tubes.

In the launching of these ships there was a peculiarity deserving of especial mention. It is, we believe, the first case where two warships were launched on the same day from a single set of ways. The vessels had been constructed one ahead of the other, tandem fashion, upon a continuous decline, the *Nashville* nearer the water, with her bow a few feet from the *Wilmington*, both vessels taking the water stern foremost. This arrangement was due to the fact that the works of the contractors, in accordance with modern notions, had been installed for the erection of ships of the largest size, the building slips being of sufficient length to accommodate a vessel 500

feet long, while the combined length of the *Nashville* and *Wilmington* is only 485 feet 3½ inches. Not only was ample space available for both ships, but it was also possible to deliver in position all the material used in their construction by a single crane, which travelled alongside on a track 80 feet above the ground. This great crane, with a lifting capacity of 60,000 lbs. at the end of the 125-foot arm, also served an adjoining similar slip, from which the steamer *Newport News* was recently launched. The *Nashville* had to travel only 250 feet before floating freely, but the *Wilmington's* sternpost had 280 feet to slide before reaching the water and 175 yards altogether before she was fully floated, the constructors having estimated that in this descent she would attain a velocity of 11 knots an hour, which is nearly equal to her best steaming speed. On account of this unusual trip for a ship to make out of her element, special precautions had been taken in the construction of her supporting cradle to obviate any derangement while in motion. Under the *Nashville* the sliding ways were 157 feet long, 19 inches broad and 15 inches thick, while under the *Wilmington*, the thickness remaining the same, the the breadth was increased to 25½ inches and the length to 176 feet.

—*The American Engineer and Railroad Journal*, November 1, 1895.

New Cruisers—France.

Two cruisers, each having a displacement of 8,200 tons and a speed of 23 knots, are about to be constructed for the French Navy. They are to be specially designed with a view to destroying foreign merchant vessels. Their armament will consist entirely of quick firing guns, of which two will have a caliber of 16 centimeters, six of 14 centimeters, and ten of 47 millimeters. The cruisers will be named respectively *Guichen* and *Châteaurenard*. The contractors are the Méditerranée and Loire shipbuilding yards.

—*United Service Gazette*, October 5, 1895.

Fast Torpedo Boats.

M. Normand, of Havre, is to be congratulated on the success of the French sea-going torpedo boat *Forban*, which last week did 31.2 knots on her trials, and thus establishes herself, for the present, as the fastest boat in existence. The trials, which took place between Havre and Cherbourg, were made at the full load displacement of 136 tons, having guns, coal, crew, provisions, as well as electric machinery on board. The first three runs were made on the measured mile at full speed to determine the number of revolutions of the twin screws required to cover the distance, and this number was utilized to ascertain the distance travelled during an hour's run, the total revolutions for the sixty minutes being divided by the mean revolutions for the mile. Thus a speed of 31.029 knots was ascertained. This is an accurate method of arriving at a result; but the vessel should have been put on the mile at the end of the run again, according to the practice in the Russian, Spanish, and other governments. The coal consumption on the hour's trial was 5940 lbs., or 2 tons 12½ cwt.

Now, the speed of the Russian torpedo boat destroyer *Sokol*, which was recently tried off the Thames, was 29.777 knots, the mean of three hours run, the first three runs on the mile having been made at 29.445 knots and the last three at 30.102 knots. A trial of three hours' duration at this high speed is much more severe than one of one hour, as in the case of the French boat. The consumption of the Yarrow boat was at the rate of 3 tons 9 cwt. per hour,

so that the French boat obviously required less power, and it was about 3200 indicated horse-power; but this is in large measure explained by the fact that the Yarrow boat is considerably larger and of great displacement. The *Forban* is 144 feet 4 inches long, 14 feet 6 inches beam, and 15 feet 2 inches deep, the extreme displacement being 136 tons. The Russian boat is 190 feet long and 18 feet 6 inches beam. Moreover, she is of stronger build for duty in heavier seas. Both boats have triple expansion engines. The one has the Yarrow water-tube boiler, while the other has Normand's boiler. The armament of the *Forban* consists of two 37 millimeter machine guns, and two tubes for launching 14-inch torpedoes.

—*United Service Gazette*, October 5, 1895.

Launch of the Victorious.

The *Victorious* is a sister ship to the *Magnificent* and *Majestic*, and is therefore the third of her class provided for by the recent votes of Parliament. She is a twin screw first-class armor plated battleship, 390 feet long between perpendiculars and more than 420 feet over all. Her breadth is 75 feet and her mean draft of water 27 feet 6 inches. Forward it is 27 feet and aft 28 feet. Her displacement is 15,000 tons. Her armor consists of hardened-face solid steel plates, like those of the *Magnificent*, launched in December last year. The central citadel, which practically includes the main body of the ship, has 9-inch plates over its sides, 14-inch forward, and 12-inch aft, with bulkheads right across the hull. The barbettes are clad with 14-inch and 7-inch armor. The casemates of the 6-inch quick firing guns are also protected by 6-inch plating. All this armor is Harveyed steel. The fore conning tower is coated with 14-inch nickel steel, and the rear conning tower with 3 inches of that metal, the communication tube being 8 inches of forged steel. The protective deck plating within the citadel has two thicknesses of 1½-inch plate, with an additional inch plate on the slopes, and this is carried well down the sides of the vessel towards the water line, and, besides tending to break up the projectiles which strike against it, will afford considerable storage space for coal. The protective plating of the fore and after parts of the deck outside the citadel is of two thicknesses of plating, respectively 1½-inch and 1-inch plates. The hull of the *Victorious* resembles to a rivet that of her predecessor in this most advanced type of modern battleship; and, although her building has not been quite so rapid, it has, nevertheless, been a remarkable performance, testifying to the activity and capacity of Chatham as one of the leading dockyards. The first plate of her keel was laid on May 28 last year, and she was put in the water within seventeen months.

The contract for her armor, about 3000 tons, has been wholly placed with Messrs. Cammell, of Sheffield, who supplied that for the *Magnificent*, and the promptitude with which a large portion has been delivered will greatly facilitate the rapid completion of this battleship.

The engines of the *Victorious*, which are being built by Messrs. Hawthorne, Leslie, & Co., of Newcastle-on-Tyne, will be of inverted vertical or overhead triple expansion type, and are to develop, working at 156 lb. to the square inch, 12,000 indicated horse-power, which should be capable of giving the ship a speed of 17½ knots under forced draft. Her coal capacity is 1890 tons, or double that of the unfortunate *Victoria*.

Her armament will be four 46-ton guns, worked by machinery supplied by Lord Armstrong's Company at Elswick, twelve 6-inch quick firing guns, sixteen 12-pounder 12 cwt. guns, two 12-pounder 8 cwt. boat and field guns,

twelve 3-pounder quick firing guns, and eight 0.45-inch Maxims. Of torpedoes she will carry seventeen of 15 inches in diameter, and five of 14 inches for boats. The ship has four submerged tubes for their discharge, and one stern tube.

The ship's complement of officers and men will be 757. She has been built under the direct supervision of Mr. G. Crocker, the Chief Constructor at Chatham Dockyard.

The only other vessel of the time honored name *Victorious* previously constructed for our navy was built in 1783 by Messrs. Perry & Co. at Blackwall. She was a wooden two-decked line-of-battle ship of the following dimensions: Length on the gun deck, 170 feet; ditto the keel, 140 feet 1⅞ inch; breadth, 47 feet 2 inches; depth of hold, 19 feet 11 inches; draft, 24 feet 6 inches; tonnage, 1659 tons. Her armament consisted of twenty-eight 32-pounders on the lower deck, thirty 18-pounders on the main beck, sixteen 9-pounders on the quarter deck and forecastle, and eight 12-pounder carronades in various positions. The speed of this battleship is recorded as 10¼ knots, her complement of men as 506, and her cost as under £100,000. The actions in which she was engaged are recorded:—In August 1795, at the capture of the Cape of Good Hope; on September 9, 1796, with the French off Sumatra, in which the enemy claimed the victory: and on February 22, 1812, with the French ship-of-the-line *Rivoli*, which she captured.

—*United Service Gazette*, October 26, 1895.

The Brooklyn.

On the 2nd October, the armored cruiser *Brooklyn* was launched from Cramp's Yard at Philadelphia. She is an enlarged and improved *New York*, being 14 feet longer, and having 1000 tons more displacement. Her dimensions are: Length, 400 feet 6 inches; beam 64.6 feet; normal mean draught, 24 feet; the engines are to develop 16,000-I.H.P., to give a speed under forced draught of 21 knots. There will be a 3-inch steel belt round the waterline, with a protective deck tapering from 6 to 3 inches. The armament will consist of eight 8-inch guns, two in pairs in turrets protected by 8-inch armor, one forward and one aft; and two on each broadside in armored barbettes, also protected by 8-inch armor; twelve 5-inch Q.F. guns in sponsoned ports on the main deck with 4-inch armor shields, and separated by splinter traverses; twelve 6-pounder Q.F. guns, and four machine guns, with five torpedo tubes. The total coal capacity will be 1753 tons, and the normal supply at ordinary draught 900 tons. The steaming radius at full speed will be 1700 knots, and at 10-knot speed 6000 knots.

—*Scientific American.*

The New Argentine Cruiser—Buenos Aires.

The official speed trials of this cruiser, which has been built for the Argentine Government by Sir W. G. Armstrong, Mitchell, and Co., at their shipyard at Elswick, took place on Saturday last off the mouth of the Tyne.

The *Buenos Aires* is a steel ship, sheathed and coppered, and is of the following principal dimensions: Length between perpendiculars, 396 feet; breadth, extreme, 47 feet 2 inches; and designed mean draught, 17 feet 7 inches, at which her displacement is 4500 tons. Her propelling machinery, which has been constructed by Messrs. Humphrys, Tennant, and Co., of Deptford, consists of two sets of four cranked triple expansion inverted cylinder engines, having 40-inch diameter high pressure, 60-inch diameter intermediate pressure, and two 66-inch diameter low pressure cylinders, all with a

piston stroke of 36-inch, steam for which is supplied by four single ended and four double ended cylindrical return tube boilers, the tubes being fitted with Messrs. Humphrys' patent ferrules.

Owing to the fog on the day of the trials, and the delay occasioned by it in getting the vessel free from her moorings, she had to be put on the measured mile as soon as she was clear of the river's mouth, and before her engines could be got up to their full speed or power. As the conditions of the trial were that the ship should run for six consecutive hours with natural draught, or with not more than ½ inch of air pressure in the stokeholds, and during that time make six runs on the measured mile with and against the tide, it was elected to make the mile runs first, and from them deduce the speed attained during the remainder of the six hours' contract running time.

The condition of the weather having prevented the vessel getting under way as early as was intended, the first two runs on the mile, which were made in 2 minutes 47½ seconds and 2 minutes 34 seconds respectively, although they exceeded the contract speed, could not be taken as a criterion of what the ship was capable of attaining, as the succeeding four runs were made at a mean speed practically of twenty-three knots an hour. The mile runs being completed, the vessel was then headed south, and the remainder of the contract time run off, the resultant mean speed throughout the whole of it being 23.202 knots an hour. During the running the engines averaged 151 and 151½ revolutions per minute for port and starboard respectively; the mean boiler pressure was 155 lb. per square inch, the vacuum 28 inch to 29 inch, and the total indicated horse-power developed 14,000.

The *Buenos Aires* is constructed with a steel protective deck throughout the whole of her length, 3 inches thick on its sloping sides, and 1½ inch thick on the flat parts, the machinery space being protected with inclined armor, 5 inches thick. For her size, the ship is very powerfully armed, as she carries four 8-inch quick firing guns on the upper deck, four 6-inch guns at the ends of the battery, six 4.7-inch guns disposed between each pair of 6-inch guns in the battery, sixteen 3-pounder guns—eight being on the main deck and four on the bridges—together with eight 1-pounder guns distributed in the tops of the two military masts. The ship is also fitted with five torpedo tubes, all above water.

—*The Engineer* (London), November 8, 1895.

The Battleship Indiana.

In placing the *Indiana* upon the list of available warships in the United States navy, the naval board will make the most important and significant addition to our fighting strength on the seas that it has ever known. In the *Indiana* we shall possess, for the first time, a first-class modern battleship that can challenge comparison with any other armorclad afloat.

It is true there are in the English navy ships of 50% greater displacement and 2 knots higher speed; but any superiority in this regard will be fairly well offset by the greater weight and more effective disposition of the armament in the boats of the *Indiana* class.

The displacement of the *Indiana* is 10,500 tons; that of the *Royal Sovereign* 14,900 tons; and yet the American ship can throw a much heavier weight of metal at a single discharge. The cause of this vast disparity in size is to be found in the different nature of the duties that have to be performed by the two types. The *Indiana* and her class are called coast defense vessels. They are designed for home waters, and their operations will be carried on as far as

possible within easy reach of the home coaling stations. Consequently they will not need to carry more than a limited supply of coal, ammunition, and general stores. On the other hand, the world-wide distribution of England's maritime interests and the aggressive system of warfare which she has always aimed to carry on, seeking out and running down the enemy at sea, necessitate the building of battleships of great coal endurance and capable of carrying a large supply of ammunition and stores for extended cruises at sea. All this necessitates an increase in size, and hence the mammoth proportions of such ships as the *Royal George*, which, when fully loaded, displaces 16,500 tons. The United States navy has no colonial interests to protect, and her battleships are designed for the special purpose of guarding the home waters. For their purpose they are ideal ships; and ship for ship, they will be fully the equal of any European leviathan in a naval duel.

The *Indiana* is 348 feet long, 69 feet beam, and draws 26 feet fully loaded. A belt of steel 18 inches thick and 7 feet 6 inches deep protects her at the water line, 3 feet 6 inches of this being above and 4 feet below water. Above this belt of steel is a steel deck, 2¾ inches thick, which, with the side armor, will form a kind of huge inverted box, under which will be placed the "vitals," *i.e.*, the engines, boilers, and stores of powder, shot, and shell. At each end of this armored box, and standing upon the steel deck, is built up a large "barbette," or round tower, of solid steel, 17 inches thick, within which will revolve the two steel turrets, 17 inches thick and 20 feet inside diameter. Each turret contains two steel guns, of a caliber of 13 inches, and 40 feet long, weighing 50 tons each. These four guns can each throw a shot weighing 1200 pounds a distance of 12 miles, and can pierce 22 inches of steel at a distance of a mile. The *Indiana* could be off Rockaway Beach and throw shells into New York City.

A little distance behind these two main turrets, and placed one at each corner of the above mentioned armored box, are built-up steel towers with armored steel turrets revolving at the top of them, in each of which are placed two 8-inch armor piercing guns. This is what, in battleship parlance, is known as the secondary battery, and it is just here that the *Indiana* shows such a preponderance of fighting strength over other warships. In every other battleship of foreign navies the secondary battery consists of guns of 6-inch caliber or less. These guns are not armor piercing, and the range of their destructive effect against a plated ship is limited. Not so the 8-inch guns of the *Indiana*. They are capable of piercing at close range all but the very heaviest armor afloat, and in a naval duel they would be the decisive factor of the fight. These eight guns are carried at a height of twenty-six feet above the water line, and could be fought in the heaviest weather without being interfered with by the breaking of heavy seas over the ship.

Between the 8-inch guns, and standing on the steel deck, are four 6-inch guns, which have a broadside and dead fore and aft fire. In addition to the heavy ordnance, the *Indiana* carries no less than thirty smaller guns, ranging in weight of shot from the 6-pounder down to the bullets of the Gatlings.

She is provided with tubes for the discharge of the deadly torpedo; and last but not least, she has a powerful underwater ram for ripping up the enemy's hull should a favorable opening occur in the confusion of a naval fight. To recapitulate, the *Indiana's* offensive strength is represented by four 13-inch 50 ton guns; eight 8-inch 18 ton guns; four 6-inch 5 ton guns; thirty

smaller rapid fire guns; 18-inch discharges for torpedoes carrying 250 pounds of explosive.

The guns are so advantageously placed that, at a single discharge, she could hurl 6800 pounds of shot into the enemy, with an average velocity of 2000 feet per second.

On her trial trip, which took place on the 18th instant, she developed a speed of 15.61 knots over a thirty mile course, which is over half a knot in excess of the contract requirement. She was quick in answering her helm and showed good stability, two most important features in a battleship.

—*Scientific American*, October 26, 1895.

H. M. S. Majestic.

We give above a drawing of the first-class battleship *Majestic*, which has just completed the last of her trials, that of thirty hours under continuous steam at sea, and now lies alongside the great fitting basin at Portsmouth Dockyard, making her final preparations for commission as flagship of the Channel Squadron.

We have already given in the columns of *The Engineer* full particulars of the constructive features, dimensions, &c., of the *Majestic* and *Magnificent*. It will suffice, therefore, to say that these two vessels, which are the forerunners of nine of the same class, are sheathed with 9-inch Harveyed steel plates for a depth of 16 feet along the sides, the armor extending from apex to apex of a pointed citadel, the length from end to end being about 300 feet. Where the armor passes around the two apices it is reinforced to 14 inches, this being also the thickness of the plating on the rest of the barbettes which arise from each end of the citadel, being founded immediately upon the armored deck. This last feature is of true turtle-back character, descending from the center line to the whole depth of a "between-decks"—about 8 feet—at the edges, thus reinforcing a streak of the ship's side to the extent of some 6 inches of Harveyed steel in thickness, over the whole of this depth. For it must be recollected that, though the deck is only 4 inches thick upon the slopes, its potential value for defense is measured by a line passing diagonally through it in its sloping position.

The length of the *Majestic* between perpendiculars is only 390 feet, but including the massive ram bow, which projects to a distance of 15 feet, and the hang over of the stern and gallery, the total length over all is about 430 feet. The beam is similar to that of the *Royal Sovereign* class—75 feet. Hence the increased length has improved the speed of the new vessels, 17.8 knots per hour having been obtained with the *Majestic*, although the indicated horse power is actually 1000 less than in the battleships of the 1889 programme. The displacement is 14,900 tons, exceeding that of any battleship afloat, in our own or other navies. The performances of the *Majestic* during her thirty hours' continuous trial were most satisfactory. Steaming gently, without any break, at an average rate of horse-power of 6075, she covered 440 knots in thirty hours; while for every indicated unit of horse-power, she consumed only 1.84 lb. of coal per hour.

The *Majestic* has a very imposing appearance afloat. The solidity of the upper battery, and the great height of the breastworks of the superstructure forward and aft, give the idea of a good deal of top hamper. As a matter of fact, however, the top hamper is quite as great in the *Royal Sovereign*, whilst the upper deck 6-inch quick-firers of the latter are only protected by ordinary shields. In the new ships there are closed-in casemates at each corner of the

battery, and even double plating above. The rise of the forecastle, which gives an extreme freeboard forward of about 23 feet, also adds to the sea-going appearance of the craft: and, during the thirty hours' run with the *Majestic*, the value of this feature was most apparent, as, though she ploughed up tons of water at the bows, the surf did not come within yards of her deck. The setting back of the bridges and chart-houses, away from the influence of the "blast" of the great guns is a most important change. It will be seen in the engraving that the conning tower, especially forward, stands clear of the bridge, so as to give an uninterrupted view all round. The position of the bridges of many of our earlier war vessels, which carry a heavy main armament, would render them most unsafe for those standing upon them when the heavy guns are fired on the beam.

The main armament of the *Majestic* consists of four 12-inch wire guns of 46 tons, two in each barbette, the breech and body of the gun being protected with a steel hood, having an extreme thickness of 10 inches in front. The method of securing the guns to their cradels is quite novel. Instead of broad bands passing over and strapping the guns on their cradles, as in the arrangement heretofore practiced, "thrust rings" are provided to the 12-inch guns, which fit into corresponding grooves in the cradles, and thus transmit the longitudinal thrust of recoil. Slots in the rings and keys keep the guns down in their places. The "thrust rings" go right round the guns, so that the guns are reversible for convenience. Another deviation from previous customs is the place for loading the guns when "run out," which affords much more room for loading operations in rear of the gun. The system of loading from fixed positions is still adhered to; but it is supplemented in the *Majestic* by an all round position, which can be adopted at pleasure, and the projectiles for which are kept ready in a revolving chamber beneath the guns, the cartridges being brought up through a central ammunition hoist. The same unfortunate feature, in regard to the mountings for the 12-inch heavy guns, is observable as in our earlier battleships—the closeness of the deck to the muzzle of the gun when firing axially direct ahead or direct astern. As a matter of fact, during the gun trials of our modern battleships the axial position is never permitted for the main armament. This is an obvious precaution; we cannot, however, but regret that such a precaution should be necessary. In action it is clear that axial firing would be the rule.

The mountings for the 6-inch quick-fire guns are of a modified pattern, and a decided improvement upon the design of those for vessels of the *Royal Sovereign* class. They are as usual in cradles, but the trunnions fit into a forging, the pivot of which passes down into a forged steel pedestal fixed to the deck. There are twelve of these guns, eight between decks in casemates, and four in the upper deck battery before alluded to, also casemated.

The 12-pounders, sixteen in number, are only protected by a very small shield, which passes round the body of the gun, and does not afford the slightest protection to the crew working the weapon. Shelter for everything has been contrived, except that necessary for the men. Elaborate armored trunks for the amm nition, as it passes up to the level of the deck, have been thought of, but the men are only covered by the slight steel sheets of the battery walls. This we cannot but think is a great blot in the design of the ship. Better to have had fewer guns, if only the upper deck battery could have had walls sufficiently thick to keep out the projectiles of small quick-firers. As matters are at present, it would be swept from end to end, only

the corner casemates might prevent a raking fire. The balance of these quick-firing 12-pounders is something most remarkable. In whatever position of training or elevation the gun is placed it remains stationary. Nothing can exceed the beauty of the working of the whole of their mountings.

The accommodation upon the *Majestic* is not, we think, equal on the whole, to that of the *Royal Sovereign* class, though certain features have been most elaborately carried out. The space upon the main deck forward is very fine, as the upper or forecastle deck rises, and gives a great deal of head-room. The sick bays are beautifully planned, and the comfort of patients has been well considered. But the cabin accommodation is rather cramped, as was a necessary consequence of having eight between-deck casemates instead of four. This is, however, unavoidable.

The masting of the *Majestic* is superb, but we should have preferred two fighting tops protected with stout steel plating to the existing four, which would afford absolutely no shelter to the crews occupying them. But the twelve 3-pounders contained in those tops would make an awful sweep of the upper decks of an enemy, so long as the gunners were able to hold out alive.

—*The Engineer*, London, October 25, 1895.

F. GENERAL MILITARY MATTERS.

Railroad Troops—Germany.

The action of railroad troops in Germany is no longer limited as it was at first to working and re-establishing ordinary railroads. The maneuvers that these troops have been put through during the summer of 1895, shows a tendency on the part of the general staff, to which they are directly attached, to use narrow gauge roads (0.65^{m}) to connect armies in the field directly with termini of railroads, which are the main arteries of lines of supply.

According to information supplied by the *Gazette de Cologne* and the *Allgemeine Militär-Zeitung*, the task laid out for the railroad brigade in the maneuvers of 1895 was the construction of a road 95 kilometers long between Jänickendorf (south of Berlin) and Loburg (near Magdeburg).

Ten companies, one of which was Saxon, and one Bavarian, were assembled for the construction, which had not been preceded by any preparatory work.

The various accounts published concerning this furnish the following details of the mode of execution:

The line of the road is laid out by the tracing section (*Tracir-trupp*). Four to ten officers, some of them mounted, start out one or two days in advance, so as not to delay the construction. If one reflects that this little party is to cover from 10 to 15 kilometers a day, some idea will be gained of the expertness in topography necessary to perform this task in country entirely unknown.

This party is followed by the *substructure company* and the *bridge company*. The first prepares the bed, if we may use that term, for the substructure is not such as civil engineers of railroads build, but wherever it is possible the natural surface of the ground is utilized. To avoid cuts and embankments steep inclines are allowed ($\frac{1}{15}$) and curves with short radii of curvature. Along with this work where bridges are needed, whether high bridges or on the level, the bridge company builds them. For this purpose, whatever material is at hand is made use of, and of course wood is most prominent. For larger bridges, for the construction of which ordinary material would not suffice, the railroad troops are provided with portable iron

bridges invented by the Prussian captain Lübbeke. A company on a war footing can build a bridge of a long span with this material in a very short time.

A bridge of this kind, 60 meters long, was constructed near Belzig in a day and a half, on the 19th of August. The fifth company of the third regiment of railroad troops was transported along with the Lübbeke material from the bridge depot at Schöneberg to Jänickendorf by the military road, and thence by the field railroad to Belzig, which was as far as the constructing had reached. Here they at once set to work to build the bridge which required but a day and a half. This rapidity of construction is due first of all to the lightness and simplicity of the parts of which the bridge is composed.

Besides bolts, screws, and other accessories for assembling, the pieces comprise bars not over two meters long, and made of rolled steel 5^{mm} thick. These can be easily carried by one man, and the construction consists simply in assembling them in successive triangles. These steel bars have a cross section like an elongated *Z*, and due to their construction, this bridge possesses such a solidity and strength that even over clear spans of 30 meters, it can support not only the double engines of the field railroad, but likewise material of war of all sorts. A bridge of this description was used in the maneuvers of 1892 in the moors of Lüneburg. For four weeks, it supported the passage of 56 trains a day without suffering any deterioration. In the maneuvers of 1895 the Lübbeke bridge was particularly tested in strength and utility by the passage over it of the heavy ordnance used in firing at Cummersdorf.

The technical advance guard which thus prepares the ground is followed by the construction companies, properly so called, which lay down the superstructure. This consists of iron rails 5 meters long. Thirty rails make a wagon load, weighing 1000 pounds and corresponding to 150 meters of rail. The entire work of unloading a wagon and putting the rails in place requires from eight to nine minutes.

Behind the carriers come the parties for assembling the rails. These fix the chairs, and wedge up where necessary generally using wood.

The first fifty kilometers on the road to Belzig was built at the rate of 10 kilometers a day. The last 45 kilometers was built in three days, or at the rate of 15 kilometers a day, but here night gangs were added. As soon as each section was finished, the road was operated, chiefly of course for hurrying up building material. There were few accidents, though the road was shaky.

This trial shows that the Germans are fully prepared to use narrow gauge railroads as field roads, and with such material that the construction will not be hindered by accidents in the terrain.

Certain organs of the press, relying on the results of these experiments, urge that this method of transport be substituted for convoys, whose long train of teams and wagons interfere materially with the rapidity of an army's movement, and whose servic is comparatively very poor. We simply mention this proposal, though it seems rather premature, based as it is on the results of an experiment in which were lacking many factors which will certainly enter in a campaign.

—*Revue Militaire de l'Etranger*, December, 1895.

BOOK NOTICES.

Recollections of a Military Life. By General Sir John Adye, G.C.B., R. A. New York, MacMillan & Co., 1895. Pp. 382. Maps, plans, and illustrations.

This is one of that pleasant and frequently valuable class of works that almost no other regular service but the English can furnish. To nearly all English officers, sooner or latter in their careers, service and foreign service are equivalent terms, and what with us would be wholly exceptional is with them a matter of ordinary expectation.

General Adye puts together plainly and simply some recollections of a service beginning at Woolwich in 1834, and ending with the command of Gibraltar in 1886. This service includes the Criméa, the Indian Mutiny, various small wars on the north west frontier, the campaign in Egypt in 1882, to say nothing of the varied peace duties in which the author was engaged as an officer of the Royal Artillery. Our interest in these recollections is not lessened by the pride of the author in the corps to which he belonged—the Royal Artillery—a corps in which members of his family "have served in uninterrupted succession from 1762 down to the present day.

Interspersed throughout the work are comments on the various political and military questions with which the author has come in contact,—comments distinguished throughout by sound common sense. In reading these one cannot but be struck by the great similarity of the attitude taken by both England and the United States toward military questions. One statement causes surprise: " * * experienced officers will concur with me that the army of 1894 is, in respect of age, superior to that of former years". The usual cry is that the ranks of the English are filled with immature young men.

Many passages invite quotations; we shall content ourselves with only one —as a tribute to the genius of John Phoenix:—"Even the placid and scientific temperament of an ordnance committee may, however, occasionally be subjected to a severe strain. Many years ago, a proposal was submitted by some invetor that a small gun, strapped broadside across a horse's back, and fired from that position, would be useful, especially in mountain campaigns. The experiment was made in the Arsenal at Woolwich, the horse's head being tied to a post, with the muzzle of the gun pointed to an old earthen butt; the committee standing on the other side of the horse to watch the result. The gun was loaded, and in order to give time, a slow-burning fuse was used to fire it. The committee, however, in tying the animal's head, had omitted to take the precaution of also making fast its tail. The first result was that, when the horse heard the fizzing of the fuse on its back, it became uneasy and walked around the post, so that the gun, instead of pointing at the butt, was thus directed straight at the heads of the committee. Not a moment was to be lost; down went the chairman and members, lying flat and low on their stomachs. The gun went off; the shot passed over the town of Woolwich, and fell in the dockyards; the horse being found lying on its back several yards away. The committee were fortunately unhurt, and gradually recovered their equilibrium, but reported unanimously against any further trial."

It is needless to add that the publishers have given the book a handsome dress. The illustrations with perhaps one exception are of no artistic value, but as they are by the author, they form a real part of his recollections. The device for reducing the recoil of heavy guns (p. 269) suggested by Napoleon III. is inserted, we suspect, only because of its imperial origin. Certainly no second lieutenant would have dared to suggest such a device. C.DeW.W.

A Technical Dictionary of Sea Terms, Phrases, and Words. Compiled by William Pirrie, London, Crosby Lockwood and Son, 1895. Pp. 354.

This work is divided into three parts, the first consisting of classified lists of terms and phrases, *e.q.*, astronomical terms, masts and spars, steering, etc.; the second of the English-French vocabulary; and the third of the French-English. The main arguments are heavy-faced, the sub-entries being in lighter type. As the arguments throughout are printed in separate lines, with their equivalents directly opposite, reference is so far made easy.

The alphabetization, however, is imperfectly and even carelessly done. Thus not only do the main arguments in some cases fail to observe strict alphabetical order, but worse, the far more numerous sub-entries follow no alphabetical order whatever. A similar error is the entry under certain heads, of words belonging to other and different parts of the alphabet. For example, who would expect to find *fulmi-coton* under *canon*? It is given, to be sure, in its proper place, but that is no reason why it should be put where no one would ever look for it. But this error is more than inexcusable when the word misplaced is not given at all in its legitimate serial position, as is the case for example, with *côtre* and *barguentin*, both found under *navire* and nowhere else.

A ten minute examination reveals many misprints; *posse* (*des ouvriers*) for *pose* (p. 129); *câble* should be masculine instead of feminine, as given; *colier* for *collier*, (p. 192); *le visse-culasse*, breach block, for *la vis-culasse*, breech block, (this word, by the way, is found under *canon*, and is not given in its proper place at all;) *embrilage* for *embrelage* (p. 201); *timber* for *limber*. (*ibid.*); *dêmâtés* for *démâtés*, (p. 226); *droit de gens*, for *des gens* (p. 231); *raisoner* for *raisonner*, (p. 244); *tarrière*, for *tarière*, (p. 337).

Some of the translations are incorrect; "*breech loading gun*", is not "*fusil à tabatière*"; it is more than doubtful if *clouer un canon*, is ever found in accurate writing for *enclouer*. *Cannonage* is not gunnery, except in a strictly limited naval sense, and *capsule* means a good deal more to-day than *percussion cap*.

It is not in a spirit of mere fault-finding that these errors (and the list could be increased) are pointed out, but in the hope that the publishers, should a second edition be called for, may subject this otherwise commendable little work to thorough revision.

The French-English part contains on a rough computation over 9000 entries, and might, we should think, prove useful to artillery officers whose studies take them afloat. The work is, however, not military in its purpose, and will in any case, prove of limited usefulness until its many errors and defects are corrected. C.DeW.W.

La Défense des Côtes d'Europe. Etude Descriptive par Carl Didelot, Lieutenant de Vaisseau. Avec un atlas de 204 cartes. Paris, Berger Levrault et Cie, 1894. Pp. 535.

The aim of this work is not, as its title would imply, to investigate the

problem of coast defense in Europe, but to furnish a statistical account of the related hydrographic and military features. In carrying out this plan, the author takes up the maritime countries of Europe in alphabetical order, and following the shore line, describes as he advances, the various elements that fall within the limits of his subject. These elements are the nature, strength, and position of the fixed defenses, the arsenals, docks, construction and repair shops, resources and supplies of all natures, depth of water, rise and fall of tide, anchorages, in short, everything that a naval commander would have to know if he were contemplating operations against any portion of the countries considered.

The value of such a work to naval officers needs no comment here. It contains within compact limits a fund of information that it would be wellnigh impossible for the ordinary student to obtain anywhere else. Great attention is naturally devoted to such countries as England, Germany, Russia and Italy, but equal or greater attention, surprising to say, is also bestowed upon France. From the point of view of completeness, this is perfectly intelligable, but this point of view is not always admissible, and least of all in France.

An atlas of 204 sketch maps accompanies the work. It is a pity that the author should have thought it unnecessary to add an index to what is on the face of it, a work of reference. C.DeW.W.

Construction der Kriegsfuhrwerke, Georg Kaiser, Professor am Höheren Artillerie-Curse, L. W. Seidel & Sohn, Wien. (3 Fl. 30 Kr. or about $1.50).

A new (October, 1895) work on the principles involved in the construction of artillery and other military carriages and wagons of all kinds, published by the Technical Military Committee in Vienna. It is a book of about one hundred and fifty pages, illustrated by forty-two figures in the body of the text, and seven additional plates of figures, being the substance of lectures delivered by the author to successive classes at the school of application for artillery officers, and constitutes a valuable contribution to the theory of carriage construction.

The subject is treated under seven sections. The first discusses the mechanics of the different modes of transportation, viz: carrying, sliding, rolling and transporting on wheels; the second investigates the effects of resistances, viz: those of the track, of the air, and of inertia, and determines the mean resistance to traction over various surfaces; the third considers the horse as motor; the fourth contains the elements of the mobility of wagons and carriages and gives in detail the principles of the construction of axles and wheels, with applications to a number of field and siege carriages; the fifth discusses the elements of draught and described the various kinds of harness and the modes of attachment to the carriage; the sixth includes an excellent mathematical investigation of the mobility of carriages, with descriptions of the systems in use in Russia, Italy, Bavaria, Austria and Sweden; the seventh deals with brakes and describes the principal kinds in use in artillery carriages, viz: the Russian, Whitworth, Krupp, Italian, Austrain, Gruson, Maxim, Röstel, French and Pindter.

The value of such a work both to the construction department (our Ordnance Department) and the arm of the service most concerned with the use of military carriages (the Artillery) is evident, but it has a far wider range of usefulness in that the first five sections contain principles of great value for all officers of the army, and which would have constant application in actual

campaigns, where wagons and carriages of all kinds are so much used. The mathematics used in the text are comparatively simple, and the descriptive parts, intended for the general reader, are carefully separated from the purely mathematical parts designed only for the constructor.

The paper and type are both excellent, and the diagrams are all that considerations of clearness, simplicity and accuracy require. Having been used for a number of years as lectures, and thus subjected to the criticism of successive classes of intelligent artillery officers, the text has been pruned of all that is superfluous, and the applications have taken an exceedingly practical turn, especially for the use of the artillery officer.

In conclusion, we take pleasure in recommending this treatise, *first*, to those engaged in the construction of vehicles, since it presents the fundamental principles on which all such construction depends, *secondly*, to the Ordnance and Artillery officers, on account of the applications to artillery carriages, and *thirdly*, to all officers of the army for the special information contained in its pages relative to the use of wheeled vehicles of all kinds. It sums up the best knowledge of the day in regard to this subject, its applications are the latest in the military world, and it will serve as a foundation for the more complicated and difficult applications to the modern engines of war in sea-coast fortifications and on board of naval vessels. J.P.W.

Transactions of the Society of Naval Architects and Marine Engineers. 12 West 31st Street, New York City. Vols. I (1893) and II (1894).

The Society of Naval Architects and Marine Engineers was organized early in 1893, and the two volumes of its proceedings are a sufficient evidence of its rapid development, its usefulness and the diligence and application of its members.

The proceedings are excellently well printed, in quarto form, bound in cloth, each volume containing about three hundred pages of printed matter, with more than sixty large illustrative plates of diagrams.

The noticeable papers (from our standpoint) are as follows:

1. *The Evolution of the Atlantic Greyhound*, by Charled H. Cramp, a very interesting history, from which we cull, in passing, the following paragraph:

"The conditions of the mail contract between the Government and the International Navigation Company place at the disposal of the navy seven great ships, almost instantly convertible into commerce destroyers, averaging greater performance than the *Columbia* and *Minneapolis*. This practically reinforces the navy by twenty-one million dollars' worth of ships, and that not only without cost of building but also without the expense of maintenance and commission in time of peace."

2. *Production in the United States of Heavy Steel Engine, Gun and Armor Plate Forgings*, by R. W. Davenport, containing not only a history of the subject, but also a brief description of the various processes in use.

3. *Steel Ships of the United States Navy*, by T. D. Wilson, late Chief Constructor, U. S. N., a masterly description and classification of all the ships of our modern navy, illustrated by diagrams of all our types of vessels.

4. *Some Suggestions of Professional Experience*, by Rear-Admiral R. W. Meade, U. S. N., in which the author discusses the relative values of the different types of ships in our new navy, in the course of which discussion he makes the following interesting remarks: "What is the first military need of this country at the present time? Is it not a perfect defense of the coast?"

And again, "The vessels that seem to be the least satisfactory to the practical men of our profession are the *Columbia* and *Minneapolis* and the *Detroit* class; the *Cincinnati* class, also, in a less degree, except for coast defense.

"And they are unsatisfactory for these reasons: the smaller vessels cannot cruise in time of war except in home waters; and as to the larger ones, such as the *Columbia*, it is feared that vessels like the *Majestic* and *Teutonic*, for instance, may laugh at our three-screw racers, which cannot cross the ocean at the same speed these commercial greyhounds maintain year in and year out (see below, 6)."

5. *Electricity on Shipboard—its Present Position and Future Development*, by S. Dana Greene, late Ensign, U. S. N., a comprehensive presentation of the latest improvements and tendencies.

6. *The United States Triple-Screw Cruisers Columbia and Minneapolis*, by George W. Melville, Engineer-in-Chief, United States Navy, a defense of the efficiency of triple screws, which the author himself originally recommended for these cruisers, the concluding words of which are significant:

"It seems very hard to satisfy our critics. Before we began the building of our new navy, it was constantly hurled in our teeth that we were behind the times; that we couldn't build as good ships as they did abroad, and so on to the end of the chapter. Now we have beaten our foreign friends, and we are told that fast ships are useless. It seems to me that the idea so clearly put by my friend Nixon, of Cramps, in regard to battleships, is equally true of fast cruisers. Explaining why we should not rely on monitors alone, he said: 'You can't get as much fight out of two million dollars as out of five'. So it is with these fast cruisers. We don't want our navy to consist of them alone, and, as I said here last year, I believe, for mere peace cruisers, we have over-speeded many of our ships; but, in time of war, I believe there is a great field for just such ships as our triple-screw cruisers—the fastest vessels now afloat (see above, 4)."

7. *The Present Status of Face-Hardened Armor*, by Captain W. T. Sampson, U. S. N., Chief of Bureau of Ordnance, a valuable paper with two appendices giving a complete summary of the results of all the tests of Harveyed plates thus far carried out in the United States and abroad.

8. *Recent Light Draught Gunboats for the United States Navy*, by J. J. Woodward, Naval Constructor, U. S. Navy, a description of the requirements to be fulfilled by Gunboats Nos. 7, 8 and 9, building at Newport News, Va., two for river use, the third a cruising gunboat for general service.

The *discussions* of these papers are often almost as valuable as the papers themselves, and the numerous *diagrams* often give information far beyond the scope of the article they are intended to illustrate.

We have referred to such papers only as are of general interest to the military student, or of particular value to the artillery officer, but, of course, the other papers are quite equal in actual merit to those mentioned.

In conclusion, it may be remarked that the society can well congratulate itself on the work accomplished in these two first years of its existence, and may look forward with satisfaction to the promises of the future. J.P.W.

Leading Events of the American Revolution, arranged by William H. Brearley. The Spirit of '76 Publishing Co., 14 Lafayette Place, New York, 1895. Pp. 32. (10 cts.).

A small pamphlet containing a summary of the landmarks in the history of

the American Revolution in a compact form conveniently arranged for reference. The events are recorded in two distinct ways, *first* by months and days, *secondly*, alphabetically, The first is not a chronological arrangement (since all the events of any one month *throughout the Revolution* are recorded under that month and *in the order of the days of the month*) but seems to be intended to show readily of what event any particular day of the year is the anniversary; the second presents at a glance the date of each event, and, of course, serves to determine quickly what day is the anniversary of any particular event.

The booklet is attractive and convenient; it will be useful to young students of American history, and contains for older readers many interesting notes not always found in school histories. J.P.W.

INDEX TO CURRENT ARTILLERY LITERATURE.

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Abbreviations employed in Index are added here in brackets.

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(*Tribune Building, New York City. Weekly. Per year* $5.00. *Single copies*, 15 *cents*).

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(96–102 *Reade Street, New York City. Weekly. Per year* $4.50. *Single copy* 10 *cts.*)

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(33 *Norfolk Street, Strand, London, England. Weekly. Per year* £2 6*d. Single copies* 6d.)

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(4-6 *Catherine St., Strand, London, W. C., England. Weekly. Per year,* £1 10*s* 6*d. Single copies* 6*d.*)

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(17 *Great George Street, London, S. W., England. Monthly. Single number one shilling.*)

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(3 *York Street, Covent Garden, London, England. Weekly. Per year* £1 12*s* 6*d. Single copy* 6*d.*)

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(Woolwich, England. Monthly.)

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(13 *Quai Voltaire, Paris, France. Semi-weekly. Per year* 18 *Fr. Single number* 5 *centimes.*)

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(37 *Rue de Bellechasse, Paris, France. Weekly. Per year* 27 *Fr. Single copies,* 50 *centimes.*)

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(55 *Rue de Chateaudun, Paris, France. Weekly. Per year* 30 *Fr. Single copies,* 60 *centimes.*)

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MARCH—APRIL.

Vol. V. No. 2. Whole No. 19.

1896.

JOURNAL

OF THE

UNITED STATES ARTILLERY

PUBLISHED BY AUTHORITY OF THE

STAFF OF THE ARTILLERY SCHOOL.

ARTILLERY SCHOOL PRESS.

FORT MONROE, VIRGINIA.

UNITED STATES ARTILLERY SCHOOL,

FORT MONROE, VIRGINIA.

"The *Journal of the U. S. Artillery* is published at the Artillery School as a bi-monthly, by authority of the Staff of the School.

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Subscription $2.50
For countries in the postal union $3.00
Single numbers $0.50

Subscriptions in all cases date from January 1st, and remittances should be sent to the editor at Fort Monroe, Virginia.

AGENTS.

NEW YORK—*Dyrsen & Pfeiffer*, successors to
F. W. Christern, 254 5th Avenue.

LONDON—*B. F. Stevens*, 4 Trafalgar Square.

JOURNAL

OF THE

UNITED STATES ARTILLERY.

VOL. V. No. 2. MARCH—APRIL 1896. WHOLE No. 19.

TESTS OF THE PNEUMATIC TORPEDO GUN AT SHOEBURYNESS, ENGLAND.

Experiments made by the Navy Department with the guns of the U. S. S. *Vesuvius* about two years ago, at Port Royal, S. C.; the mounting of a pneumatic gun on the *El Cid*, a vessel fitted out in New York for Brazil during the recent war in that country; and the recent trials of a battery of three guns now mounted at Sandy Hook, New York Harbor, have quickened the general interest in this somewhat novel instrument of warfare. Experiments, which first attracted wide spread public attention, were made as far back as September 20th, 1887, at Fort Lafayette, when the coast survey schooner *Silliman* was destroyed by three shots from an 8-inch pneumatic gun. Since that date trials and experiments have been made from time to time which have never failed to interest those who are watching the gradual development of modern war appliances, on account of the tremendous destructive power of the weapon and the many novel features of the whole pneumatic system.

One new thing creates a demand for another; thus the gun required a new type of carriage, and a new type of projectile to contain the large charge of explosive. Again, the projectile required a new type of fuse. The storage of large quantities of air under high pressure made necessary a new and strong reservoir to contain it. We might multiply instances of this kind. Rarely has a new invention developed a greater number of interesting mechanical problems in the perfection of its details. During the summer of 1890, one of these guns of the same type as those now mounted at Sandy Hook, was sold to the

English Government. It was mounted upon a temporary foundation at the Shoeburyness proving ground and tested by firing 89 rounds with dummy projectiles. Afterwards it was taken to Milford Haven for experiments with high explosives.

It is the purpose of this article to describe in detail, the tests made at Shoeburyness.

All experiments made at the proving ground are directed by the Ordnance Committee of which General Hay was chairman at that time. Colonel Stewart Nicholson was in command at Shoeburyness and he frequently superintended the tests personally, always taking a great interest in them. Major Perrot was first experimental officer and he usually sighted and manipulated the gun until he was succeeded by Captain Elmslie.

The Shoeburyness Proving Ground is located on the north side of the estuary of the Thames and extends along that portion of the coast known as the Maplin Sands. The location is unique and particularly well adapted to the purposes of a proving ground. The Maplin Sands are a very level stretch of coast, eighteen miles long and nearly two miles wide, covered at high tide with about six feet of water and at low tide left "high and dry." The tide water begins to flow over the sands at about mean tide so that half the time, during two periods each day, the sands are dry, the other half of the time they are covered with water. They are so nearly level that the tide water will cover them completely in from fifteen to thirty minutes. It frequently happens that men working on the sands will be caught by the inflowing water before they can ride in on horse back. The sands are composed of a hard, compact gravel, so firm that horses can be ridden or carts driven over them without sinking.

All firing is done over this level beach and it is possible to have a land or water range by selecting the proper hour of the day for firing according to the tide. When the object of the experiment in hand is to determine accurately the range of a shot, it is desirable to fire over land in order that the point of striking may be exactly located and the distance measured from the gun. Again, if the experiment is to determine the action of a fuse upon impact with the water, it is necessary to fire over the water and very desirable to recover the fuse, which can be done at Shoeburyness after the tide recedes. Thus it will be seen how all the advantages of a land and water range are combined in one location.

All experimental firing with the pneumatic gun was done over the dry sands when the tide was out since the principal object of

the experiments was to determine accurately the range of different projectiles, discharged at varying angles of elevation and with varying adjustments of the valve; also to determine how closely shots could be grouped when discharged under similar conditions of pressure, elevation, cut-off, etc., this being the true test of accuracy of the gun.

No experiments were made here with shells charged with high explosives, there not being sufficient depth of water for submarine explosions and the proximity of dwelling houses prevented explosions against earthworks or solid targets.

A brief description of the gun may not be out of place here:

The gun, using the term in a broad sense that includes the entire piece of mechanism, consists of four essential parts, viz: the barrel, with its supporting truss and breech mechanism; the carriage, including the traversing and elevating gear; the reservoirs, containing the compressed air, including pipes that connect them with the barrel; and the system of discharging valves that control the escape of air from the reservoirs into the barrel.

The barrel is fifty feet in length—fifteen feet in rear and thirty-five feet in front of the trunnions—fifteen inches diameter of bore and about 1¼ inches thick. It is made of the best cast gun iron, in three sections with flanged ends bolted together. Its extreme length and lightness makes it necessary to support it on a truss, which is built up of steel angle irons and plates. From the trunnions to the breech the barrel is surrounded by a cast iron casing that forms a part of the air reservoir and serves to conduct the air from the trunnions to the barrel at the breech. The supporting truss and the trunnions are attached to this casing. By this construction, it is possible to align the barrel after all parts are assembled since it does not have to support its own weight.

Six rectangular lantern openings are made in the barrel near the breech for the air to enter in rear of the projectile from the casing that surrounds the barrel. These openings are normally closed by a steel sleeve, technically termed the main valve, which slides longitudinally upon the outside of the barrel and inside of the casing. The operation of this valve will be described later on. The breech is closed by a convex disc, having five radial lugs on its periphery that engage five corresponding lugs on the barrel. To open the breech this disc is turned one tenth of a revolution and then swung outward to one side, a motion that is easily and quickly made. The mechanism is extremely simple,

consisting of only three essential parts: the disc, hinge, and handle.

The carriage is rigidly built of steel plates, stiffened by angle and channel irons. Two hollow cheek pieces support the trunnion bearings and are mounted on four I-beams that run crosswise and tie them together. The whole box structure is mounted on four castings containing six conical wheels upon which the carriage turns and four wheels with vertical axes which center the carriage in the bed ring. The bed ring, upon which the wheels run, is set deep into the concrete foundation and is secured by twenty-four 2-inch bolts. It contains a circular rack for traversing.

The carriage contains an electric motor with suitable gearing for traversing and elevating. The gunner, who sights the piece, stands upon a platform at the left side of the carriage and controls the electric motor by means of a hand wheel connected with a rheostat located underneath the platform upon which he stands. A handle within reach of the gunner puts the electric motor in gear with the elevating worm or the traversing pinnion by means of friction clutches. Should any accident occur to the electrical system, two crank handles on the right and front side of the carriage are provided for traversing and elevating the piece by hand power.

The compressed air for propelling the projectile is contained in eight wrought iron flasks located in two chambers under the ground, one on each side of the gun platform, four flasks being placed in each chamber. The pipes leading from these flasks up through the carriage to the barrel also form a part of the air reservoir. The air flasks are about twenty-five feet long, sixteen inches outside diameter and nine-sixteenths inches thick. They are made from lapwelded iron plates with a solid head welded into one end, the other end having a flange with a large opening. Four of these air flasks are connected together by a manifold casting and the two manifold castings are connected by long pipes to an inverted T casting located directly underneath the center of the gun. From this T casting the air is conducted by a pipe, sixteen inches in diameter, up through the carriage to the hollow trunnions. Since the gun must be moved in a horizontal and vertical plane, it is necessary to have three movable joints in the air pipe. Two of these joints are at the trunnions and a third at the center of the racer ring. These movable joints are of large dimensions, sustaining an air pressure of one thousand pounds per square inch and they must allow the gun to

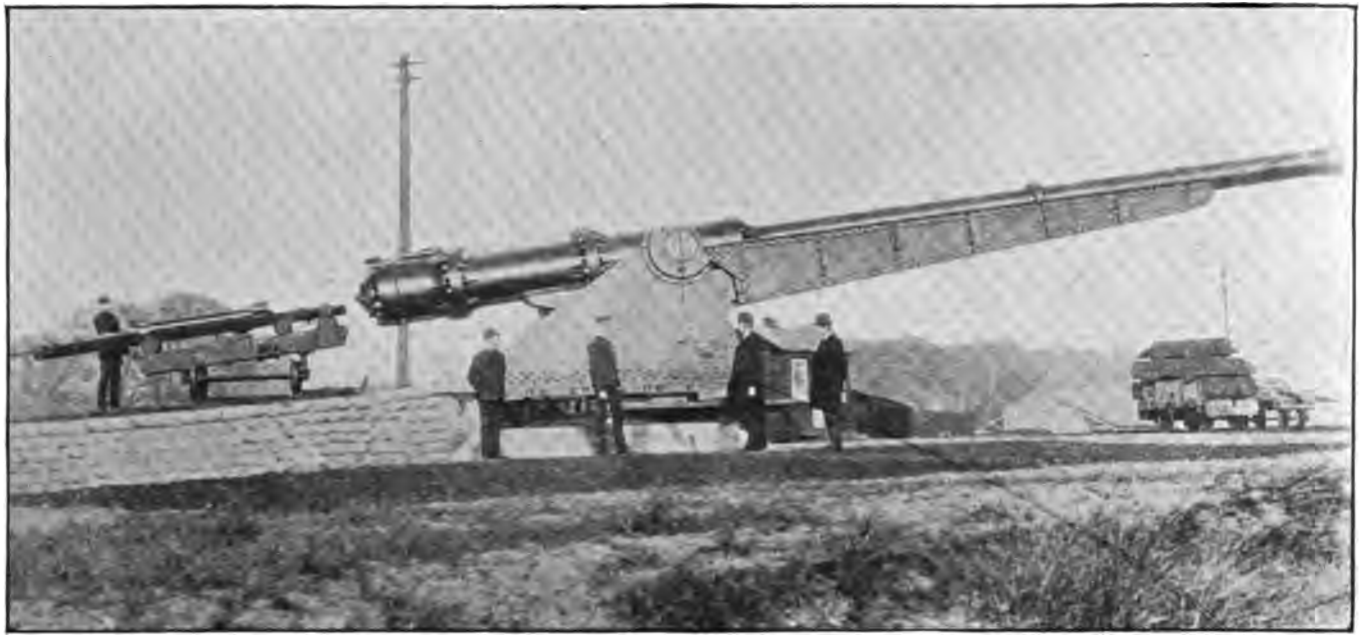


FIG. 1.

15-INCH PNEUMATIC GUN.

Errected at Shoeburyness.

move without great expenditure of power. It would be difficult to describe their construction without the assistance of detail drawings, but I may say that they are packed with double "cup leathers" that have oil between them, under a pressure somewhat higher than the pressure of the compressed air. This excess of pressure is automatically maintained by supplying the oil from a small differential accummulator located in the carriage. The air pressure forces the plunger of the accummulator down upon the oil, and since the diameter of the upper end of the plunger upon which the air acts is a little larger than the lower end bearing upon the oil, the pressure of the oil per square inch is greater than the pressure of the air. Similar hydraulic packings are used about the main valve.

The valve, already referred to, that controls the escape of air from the reservoir into the barrel is located at the breech. Its operation when started is entirely automatic and it might properly be termed a time valve; that is to say, it can be adjusted to partially or wholly open, and remain open for a definite length of time and then close; thus it is possible to allow five, ten, fifty or any number of cubic feet of air to escape by a simple adjustment. This is analogous to a variable "cut off" in a steam engine. We can set the valve to close when the projectile has traveled one-quarter, one-half, three-quarters or any other fractional part of the length of the barrel. It will be readily understood that this affords a means of changing the range of the projectile without changing the elevation of the piece, for the muzzle velocity depends upon the energy stored in the projectile and this energy depends upon the amount of air that enters the barrel while the projectile is traveling through it. It is, in some respects, analogous to varying the amount of powder used in mortar firing. The adjustment of the valve is indicated by an index wheel located within reach of the gunner and the valve is opened or set in operation by pulling a lever at the left trunnion within reach of the gunner when he stands upon the platform to sight the gun.

The valve is too intricate in its action to be described without drawings and such a description would be out of place in this article; suffice it to say that the large sleeve, or the main valve, covering the ports in the barrel, before mentioned, is moved by unbalancing the pressure on its edge and this is done by a proper movement of a small auxiliary valve. The time of opening and closing depends upon the time required for air to flow through a small orifice and fill a chamber of fixed dimensions.

By changing the size of this orifice the time is changed and the size of the orifice is adjusted by a micrometer screw. Turning the index wheel, which can be reached from the platform, turns this micrometer screw and opens or closes the orifice. The operation is termed "setting the valve." The micrometer screw is graduated into 900 equal and arbitrary divisions which are neither directly proportional to the areas of the orifice nor to the losses of pressure, but require calibration experimentally by discharging the gun and determining the loss of pressure corresponding to each division of the micrometer. When this relation is known, it can be represented by a curve plotted with "losses of pressure" as ordinates and "valve settings" as abscissas. Such a curve is shown on Plate I. This relation between the "loss of pressure" and "valve setting" is not constant, but varies with the temperature, the condition of the valve, etc., but it is nearly constant for any single day and it varies only slightly from day to day.

The auxiliary valve interlocks with the breech block by means of a sliding bolt thus making it impossible to discharge the gun when the breech is open.

Should the main valve leak from any cause, such as dirt lodging on its seat, the escaping air would, after the gun is loaded and the breech closed, slowly push the projectile along the bore were it not for an escape valve that is provided to prevent such an accident. This valve is attached to the barrel just forward of the breech block and normally stands open to allow the free escape of any leaking air. When the gun is discharged the sudden rush of air closes this valve until the pressure in the barrel falls nearly to atmospheric when it again opens.

For permanent emplacements a circular track encircles the gun upon which the loading carriage runs. At Shoeburyness only a short arc of this track was built in rear of the gun, raised to the proper level for loading. The gun is always brought to an angle of seven degrees with the horizontal for loading, the height and slope of the loading carriage having been designed for this angle.

A platform fifty feet in length and from six to ten feet in width extended in rear of the gun. Upon the end of the platform, farthest from the gun, were racks for the storage of projectiles and a narrow-gauge track was laid on the platform extending from the loading carriage to the racks with a switch and two branches on either side of the racks. Two loading trays ran up this track conveying the projectiles from the racks to the

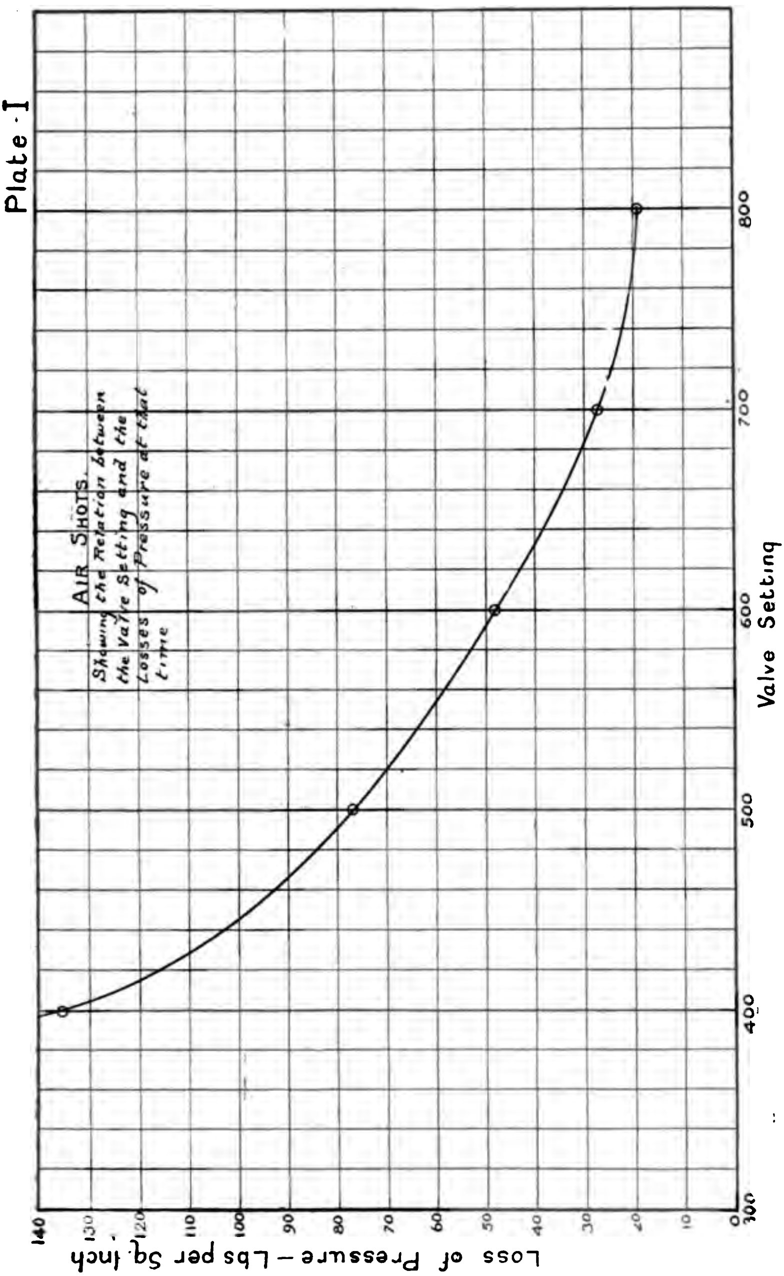


Plate - I
AIR SHOTS.
Showing the Relation between the Valve Setting and the Losses of Pressure at that time
Valve Setting
300
400
500
600
700
800
Loss of Pressure – Lbs per Sq. inch
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140

loading carriage, which was in turn pushed around on the circular track until the projectile was brought in line with the gun. Ordinarily a sergeant and six men were detailed to do the loading, but when rapid loading was required ten or twelve men were used. The movements that had to be executed in loading were to place the projectile in the loading tray, run the tray up the tracks upon the loading carriage, push the loading carriage, tray, and projectile around into line with the gun (the gun in the meantime having been brought to the loading angle), open the breech, throw a wire rope attached to a windlass on the loading carriage over the projectile and secure it to a ram that runs on the loading tray, push the projectile into the bore by turning the crank handles of the windlass, withdraw the loading ram, push the loading carriage to one side (in line with the return track upon which the loading tray runs back to the projectile rack), close the breech and elevate the gun. Several of these movements could be performed by different men at the same time. When loading rapidly, two loading trays were used in order that a projectile could be placed in one while the other was delivering a projectile to the gun, thus saving a little time.

A corrugated iron building was erected about 200 feet from the gun which contained two locomotive-type boilers, a small Brotherhood air compressor such as is used on board torpedo boats, and an engine and dynamo. The dynamo supplied the electric current for operating the electric motor in the gun carriage when elevating and traversing the gun. The same dynamo also supplied current for lights in the engine house. An air storage reservoir was located just outside the building, consisting of ten wrought iron flasks about 25 feet long, 16 inches outside diameter, and $\frac{18}{16}$ inch thick. Their total capacity was about 250 cubic feet and they were usually filled with air to 2000 pounds per square inch. Each reservoir flask was connected by a small copper pipe to a common manifold. A stop valve in each copper pipe made each flask independent. The air compressor was connected to the manifold with a "separator" interposed to remove any oil or water from the compressed air. The manifold was also connected to the gun reservoir by a 1½ inch iron pipe with a large stop valve in it. Two pressure gauges were used, one attached to the manifold to indicate the pressure in the storage reservoir and the other attached to the pipe leading to the gun reservoir to indicate the pressure therein. It was by the readings of the latter that the initial and final pressures, given in the tables later on, were determined. By manipulating the various

stop valves just mentioned, compressed air could be pumped directly into the gun reservoir, or into any of the storage reservoir flasks or be allowed to flow from the storage into the gun reservoir. After each discharge of the gun the pressure in the gun reservoir was restored to 1000 pounds per square inch by opening the cock and allowing air to flow from the storage into the gun reservoir.

The Ordnance Committee prepared the following program of the test which was adhered to except in one or two instances. Part 2, of the program, which calls for firing at three different pressures, was changed to three different valve settings:

PROGRAM.

Fire as follows:

1. Range and accuracy—dummy shell,

Pressure, 1000 lbs.

(*a*) With light shells.

5 rounds at 15° Take velocity of 3 rounds.
5 rounds at 20°
5 rounds at 25°
5 rounds at 30°

(*b*) With medium shells.

3 rounds at 15° Take velocity of 3 rounds.
5 rounds at 20°
3 rounds at 25°
5 rounds at 35°

(*c*) With heavy shells.

3 rounds at 15° Take velocity of 3 rounds.
5 rounds at 25°
3 rounds at 35°

2. Range and accuracy. Fixed angle of 20 degrees.

Fire with three different pressures. 3 rounds at each pressure, with each nature of shell (actual pressures to be determined after 1 has been carried out).

9 light shells,
9 medium shells,
9 heavy shells.

3. Fire at earth parapet at 1000 yards range.

2 light shells
2 medium shells } Dummy shells weighted.
2 heavy shells

Note penetration to guide trial of loaded shells. Three similar loaded shells to be afterwards exploded in earthwork at Lydd, to obtain comparative effect.

Throughout the trials the following readings and observations were taken: Initial pressure, final pressure, range, deviation, time of flight, velocity and direction of the wind, thermometer, barometer.

The character of the flight of the projectile was always noted.

The first four measurements were made with great precision and this gives great value and weight to the trials.

The pressure gauge which indicated the initial and final pressures, that is the air pressure in the gun reservoir before and after discharging the gun, was very sensitive and had a large dial graduated with two-pound divisions from 0 to 1250 pounds and half divisions could be easily estimated. The error of these readings was probably not more than $\frac{2}{10}$ of one per cent and often not as great as this. The initial pressure could be read more accurately than the final on account of the change of temperature of the air immediately after discharging the gun, as will be explained more fully later on.

In order to measure ranges with precision, a line of fire was laid out from the gun across the sands by the Engineer Corps, and pegs were driven at each hundred yards with the distance of each peg from the gun branded on it. Immediately after firing a shot the range sergeant rode to the point of impact. If the shot struck on the line of fire, he simply measured the distance to the nearest peg with a two-yard stick and recorded the same in his note book. In case the shot did not strike on the line of fire, or nearly so, he then projected the point of impact on the line of fire by means of a large wooden square fifteen or twenty feet long on each side, which was laid down on the sands. Having done this, the distance was then measured along the line of fire to the nearest peg. The deviation was measured from the point of impact, along the perpendicular to the line of fire. The error in measuring ranges was probably not greater than one part in three thousand or one foot in one thousand yards. The errors in measuring deviations may have been one part in one hundred.

Times of flight were measured in the usual manner by stop-clocks. One hand of the clock revolved once per second over a dial divided into one hundred divisions. So much depends upon the observer that it is impossible to state the magnitude of the errors, but they were probably less than one half second. In case there were two observers, the readings of both have been given in the tables. The stop clocks were regulated by allowing them to run for half an hour or more and comparing them with a standard clock.

The wind was a disturbing element and a very difficult one to measure with any degree of accuracy. The velocity was measured with the usual form of cup anemometer, erected on a pole near the gun. During the later experiments it was also measured with another instrument held in the hand of the range sergeant out on the sands not far from the point where the projectile struck. The readings of both instruments are given in the tables and they are often times very different. Since the firing was almost always at high angle, the velocity of the wind may have been and probably was very different at the highest point of the trajectory. A flag near the gun showed the direction of the wind.

Readings of the thermometer and barometer were always taken.

The character of the flight of the projectiles was carefully noted by observers stationed near the gun in a good position to follow the projectile throughout its flight except when the angle of elevation was very high and the range very long.

In order to lay the gun on the line of fire a wooden cross, with a "bull's-eye," was set up on the sands about five hundred yards from the gun and to the left of the line of fire a distance equal to the distance between the axis of the barrel and the axis of the telescopic sight, so that when the sight was properly adjusted and the intersection of the cross-hairs of the telescopic sight coincided with center of bull's-eye the axis of the barrel coincided with the line of fire. The use of the telescopic sight made it possible to lay the gun much more accurately than could be done with the ordinary open sights and great care was always taken in the laying.

Elevation was given by a quadrant and sensitive spirit level which form a part of the telescopic sight. The quadrant could be read by means of a vernier to one minute of arc and the spirit level attached would show a change of level less than a minute of arc.

The valve setting or method of adjusting the cut-off of the main valve which controls the amount of air that enters the barrel at each shot has been already explained.

In the experiments about to be described, three sizes of weighted projectiles were used; the first and largest weighed 976 pounds, its body filling the bore of the gun. It is guided, while flying through the air, by spiral vanes on the end of a tube attached to and extending in rear of the projectile body. This

is shown in figure 2. Projectiles of this size are designed to contain 500 pounds of high explosive.

The second in size was, what is termed a sub-caliber projectile, weighing 493 pounds. Its outside diameter was 10 inches. A wooden disc loosely attached to the base served to fill the bore and center the projectile at its rear end, the point end being centered by four wooden blocks that fall off as it leaves the muzzle. These blocks have a stud entering into the head of the projectile which compels them to move forward in the bore; figure 3 shows a ten inch sub-caliber ready for loading and figure 4 the same during flight. The spiral flanges or wings at the base give rotation as it moves through the air and thus keep it always tangent to the trajectory. Projectiles of this size contain 200 pounds of high explosive.

The third and smallest size projectile, weighing 298 pounds, is sub-caliber and in every repect similar to the one just described, except that it is eight inches in diameter and designed to carry 100 pounds of high explosive. This is shown in figures 5 and 6.

In accordance with the program already given 31 8-inch, 27 10-inch sub-caliber and 22 15-inch full caliber projectiles were provided for the trials. These were supplied by the British Government and were made at the Royal Laboratory, Woolwich Arsenal. The points were of cast iron with a dummy fuse. The tubes which form the projectile's body were made from steel plates rolled up, riveted and brazed together; afterwards straightened as much as possible by hammering. Two pieces of tube were used for each projectile, joined together in the center by riveting to a narrow band inside.

The wing pieces of the sub-calibers were of gun-metal finished all over. The full calibers had cast iron bases with wings of steel $\frac{1}{16}$ inch in thickness riveted to gun-metal spiders, which in turn, were secured to a piece of boiler tube of smaller diameter and this was attached to the base of the projectile by entering a socket and being held there by two taper pins. The wings were originally held by copper rivets to the gun-metal spiders. The after-blast of air, as the projectile left the muzzle, tore off the wings of one or two. The wings of the remaining projectiles were secured with iron rivets. They held much better, but several were torn off.

The interior of the projectiles was filled with blocks of oak secured in place by screws put through the tubes from the outside. The sabots or gas-checks placed in rear of the sub-calibers were

FIG. 2.

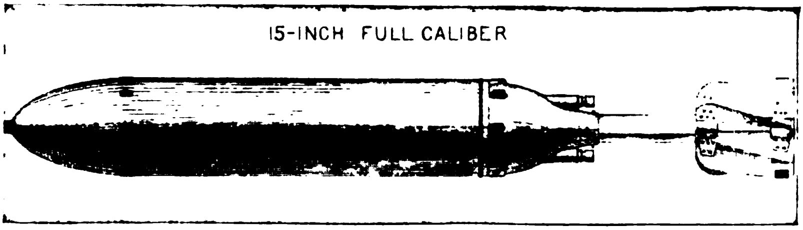
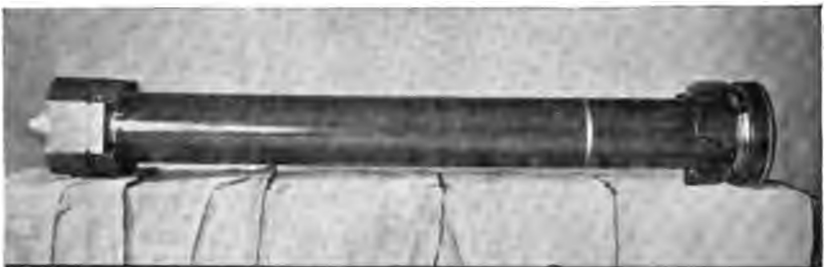


FIG. 3.
10-INCH SUB-CALIBRE PROJECTILE READY FOR LOADING



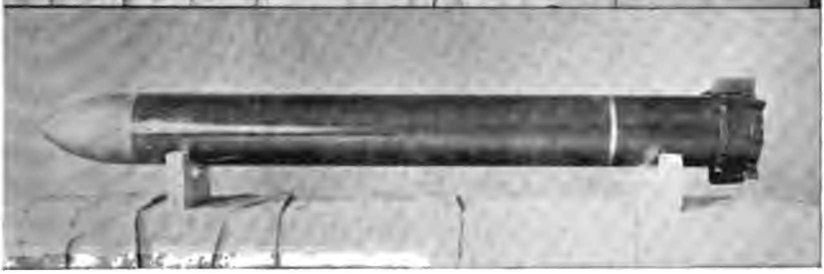


FIG. 4.
10-INCH SUB-CALIBRE PROJECTILE IN FLIGHT.

FIG. 5.
8-INCH SUB-CALIBRE PROJECTILE READY FOR LOADING.

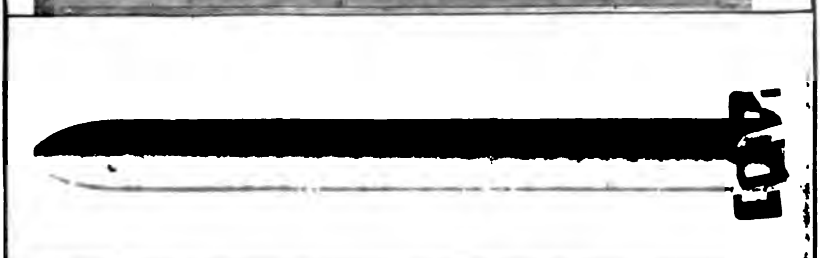


FIG. 6.
8-INCH SUB-CALIBRE PROJECTILE IN FLIGHT.

made of oak faced with a brass ring where they bore against the projectile base and having a cup leather attached to their periphery. To the center of the gas-check was attached a piece of gas pipe 14 inches long, which served as a distance piece to prevent the projectile sliding back in the bore against the breech block, thus giving space for the air to enter the bore between the gas-check and the breech block. In the case of full calibers, they were placed in the bore with the wings against the breech block and the air entered through the wings. (See figure 2).

The gas-checks of the sub-calibers were attached to the base of the projectile by four 1/4-inch iron screws that were sheared at the instant of discharge, thus allowing the gas-check to separate from the projectile as it leaves the muzzle.

The four guide blocks that center the points of the sub-calibers in the bore, were made of white pine with a bronze stud on the under-side and at the rear end of each, that entered four corresponding holes in the projectile near the ogival head. The guide

PROJECTILES.

Table of Dimensions and Weights.

	FULL CALIBER.	10-INCH SUB-CALIBER.	8-INCH SUB-CALIBER.
Length from point of fuse to base of wings.	10 ft. 2 1/8 in.	7 ft. 7 1/16 in.	6 ft. 5 in.
Length of fuse protruding from the point.	1 1/4 in.	1 1/4 in.	1 1/4 in.
Outside diameter.	14.94 in.	10.25 in.	8.27 in.
Center of gravity from point of fuse.	48 5/8 in.	40 1/4 in.	36 1/2 in.
Center of gravity, per cent of total length.	39.81%	43.96%	47.4%
Length of wings.	15 in.	6 in.	5 1/2 in.
Pitch of wings, (approximate).	1 turn in 12ft.	1 turn in 18 1/2 ft.	1 turn in 15ft.
Thickness of body tube.	3/16 in.	3/16 in.	3/16 in.
Total weight exclusive of guide blocks and gas-check.	976 lbs.	493 lbs.	298 lbs.
Weight of guide blocks.	. . . . . .	8 lbs. 8 oz.	11 lbs. 8 1/2 oz.
Weight of gas-check.	. . . . . .	28 lbs. 1/2 oz.	28 lbs. 1 1/2 oz.
Total weight including gas-checks and guide block.		529 lbs 8 1/2 oz.	337 lbs. 1 oz.

blocks were held in place by rubber bands until they were entered into the bore, when the rubber bands were cut and removed, the bore of the gun then serving to keep the blocks in place.

The exterior of the projectiles was covered with a coat of thick paint to fill any small unevenness and give them a smooth surface. Lead weights were placed inside the heads to adjust the position of the center of gravity.

Before any of these projectiles were fired, the attention of the Ordnance Committee was called to the fact that they were not cylindrical; that they were not in perfect running balance and that in some of them the lead weights in the interior were loose, for they rattled about. The subject was considered by the Ordnance Committee and they, not wishing to delay the experiments or be at the expense of making new projectiles, decided to use them as they were, taking note of their imperfections.

The following tables, I to XIV give all the important data of the trials. The shots are not arranged in the order in which they were made, but have been grouped with reference to the size of projectiles, elevation of the gun and the valve setting; for example, table I contains the data of all shots made using 8-inch sub-caliber projectiles at 15° elevation and a "valve setting" of 450 (arbitrary scale).

I.

EIGHT-INCH SUB-CALIBER PROJECTILE.

Initial Pressure, 1000 lbs. per square inch.
Elevation, 15° above horizontal. 15° 8′ above the target.
Valve setting 450 (arbitrary scale).

Date.	Number.	Loss of pressure. lbs.	Range. yards.	Range error. yards.	Range error. per cent.	Deviation. yards.	Time of flight. sec.	Velocity of wind. f.s.	Direction of wind.	Thermometer. Fah.	Barometer.
January 20.	1	146	2910	—21	0.71	16.4 L	. . .	15	4	39°	29.89
" "	2	148	2906	—25	0.85	3. L	12.78	14	4	39	29.89
" "	3	146	2935	+ 4	0.13	3.6 L	12.76	14	4	39	29.89
January 30.	6	120	2951	+ 20	0.68	12.4 L	12.90	10	4	43	30.03
" "	7	123	2955	+24	0.82	8.6 L	12.90	10	4	43	30.03
		Mean	2931								

Remarks—Flight excellent.

The greater ranges on January 30th probably due entirely to atmospheric conditions.

II.

EIGHT-INCH SUB-CALIBER PROJECTILE.

Initial pressure, 1000 lbs. per square inch.
Elevation, 20° above horizontal. 20° 6′ above the target.
Valve setting (June 2nd) 400 and (January 30th) 450.

Date.	Number.	Loss of pressure. lbs.	Range. yards.	Range error. yards.	Range error. per cent.	Deviation. yards.	Time of flight. sec.	Velocity of wind. f.s.	Direction of wind.	Thermometer. Fah.	Barometer.
June 2.	1	119	3735	—7	0.19	21 L	17.05	2	6	70°	29.94
" "	2	120	3740	—2	0.05	4 L	16.98	2	6	70	29.94
" "	3	118	3750	+8	0.21	1 R	. . . .	2	6	70	29.94
. . .	.	mean	3742	. .	. . .	. . .	17.01	. .	. .	. .	. . .
Jan. 30.	1	124	3647	+3	0.08	17.2 L	16.80	7	4	43	30.03
" "	2	123	3643	—1	0.03	20.8 L	16.80	7	4	43	30.03
" "	3	124	3647	+3	0.08	18.6 L	16.80	10	4	43	30.03
" "	4	125	3640	—4	0.11	22.6 L	16.80	10	4	43	30.03
" "	5	125	3644	0	0.00	21.2 L	16.80	8	4	43	30.03
		mean	3644				16.80				

Remarks—Flight excellent.

III.

EIGHT-INCH SUB-CALIBER PROJECTILE.

Initial pressure, 1000 lbs. per square inch.
Elevation 25° above horizontal. 25° 5′ above the target.
Valve setting 450.

Date.	Number.	Loss of pressure. lbs.	Range. yards.	Range error. yards.	Range error. per cent.	Deviation. yards.	Time of flight. sec.	Velocity of wind. f.s.	Direction of wind.	Thermometer. Fah.	Barometer.
March 5.	4	117	4292	+ 2	0.05	16.6 L	20.9?	33	6	5[illegible]	30.28
" "	5	120	2618	. .	. . .	12.8 R	17.8	37	6	55	30.28
" "	6	119	4274	—16	0.37	12.8 L	. . .	37	6	55	30.28
" "	7	120	4302	+12	0.28	10.8 L	. . .	39	6	55	30.28
" "	8	118	4293	+ 3	0.07	22.8 L	. . .	37	6	56	30.28
Mean (neglecting No. 5)			4290				20.9?				

Remarks—In round No. 5 the gas-check failed to detach from the projectile; all the others had steady flights.

IV.

EIGHT-INCH SUB-CALIBER PROJECTILE.

Initial pressure, 1000 lbs. per square inch.
Elevation 34° above horizontal. 34° 5′ above the target.
Valve setting (February 13) 400, (January 29) 450.

Date.	Number.	Loss of pressure. lbs.	Range. yards.	Range error. yards.	Range error. per cent.	Deviation. yards.	Time of flight. sec.	Velocity of wind. f.s.	Direction of wind.	Thermometer. Fah.	Barometer.
Feb. 13.	1	149 ?	4744	. .	. . .	5.4 L	26.78	12 on range 8 at gun.	9 8	44°	30.44
Jan. 29.	2	124	4981	—13	0.26	98.2 L	. . .	25	4½	45.	29.94
" "	1	124	5007	+13	0.26	103.6 L	. . .	31	4½	45	29.94
. . . .	.	. .	4994	. .	. . .	. . .	. . .	. . .	. .	. .	. . .

Remarks—Flight excellent.

V.

TEN-INCH SUB-CALIBER PROJECTILE.

Initial pressure 1000 lbs. per square inch.
Elevation 15° above horizontal. 15° 10′ above the target.
Valve setting 450.

Date.	Number.	Loss of pressure. lbs.	Range. yards.	Range error. yards.	Range error. per cent.	Deviation. yards.	Time of flight. sec.	Velocity of wind. f.s.	Direction of wind.	Thermometer. Fahr.	Barometer.
January 22.	1	126	2290	— 5	0.22	7.6 L	11.1	29	7½	41°	29.57
" "	2	132	2290	— 5	0.22	7.6 L	11.2	29	7½	41	29.57
" "	3	131	2315	+20	0.90	8.8 L	11.4	28	7½	41	29.59
		Mean =	2295				11.2				

Remarks—Flight excellent.

VI.

TEN-INCH SUB-CALIBER PROJECTILE.

Initial pressure 1000 lbs. per square inch.
Elevation 20° above horizontal. 20° 8′ above the target.
Valve setting 450.

Date.	Number.	Loss of pressure. lbs.	Range, yards.	Range error. yards.	Range error. per cent.	Deviation, yards.	Time of flight. sec.	Velocity of wind. f.s.	Direction of wind.	Thermometer. Fah.	Barometer.
March 6.	1	105	2914	— 8	0.27	15.2 L	14.95	10 on range 18 at gun	5	53°	29.94
" "	2	114	2940	+18	0.61	12.2 L	15.10	12 on range 22 at gun	5	51	29.94
" "	3	115	2913	— 9	0.31	18.4 L	15.00	10 on range 17 at gun	5	51	29.94
Mean =			2922				15.02				

Remarks—Flight of Nos. 1 and 3 slightly unsteady.

VII.

TEN-INCH SUB-CALIBER PROJECTILE.

Initial pressure 1000 lbs. per square inch.
Elevation 25° above horizontal. 25° 7′ above the target.
Valve setting 450.

Date.	Number.	Loss of pressure. lbs.	Range, yards.	Range error. yards.	Range error. per cent.	Deviation, yards.	Time of flight. sec.	Velocity of wind. f.s.	Direction of wind.	Thermometer. Fah.	Barometer.
Feb. 18.	1	132	3268	. .	. . . .	75.6 L	. . .	fog	. .	34°	30.66
" "	2	137	3278	. .	. . . .	78.4 L	. . .	fog	. .	34	30.66
" "	3	138	2816	. .	. . . .	43.6 R	. . .	fog	. .	34	30.66
Mean (neglect'g No. 3)			3272								

Remarks—As these three shots were made in the fog the flight could not be observed. The ranges and deviations were measured after the three shots were made, so it is not known in what order they should be written. It is more than probable that the flight of one projectile was defective in some way, thus accounting for the short range of 2816 yards.

VIII.

TEN-INCH SUB-CALIBER PROJECTILE.

Initial pressure 1000 lbs. per square inch.
Elevation 34° above horizontal. 34° 6′ above the target.
Valve setting (February 13th) 350, (January 22) 450.

Date.	Number.	Loss of pressure. lbs.	Range. yards.	Range error. yards.	Range error. per cent.	Deviation. yards.	Time of flight. sec.	Velocity of wind. f.s.	Direction of wind.	Thermometer. Fah.	Barometer.
Feb. 13	2	184	3866	. . .	. . .	5.6 L	23.54	12 on range 13 at gun	10 8	44°	30.44
Jan. 22.	9	126	3958	+ 10	0.25	21.8 R	24.7	26	7	40	29.57
" "	10	129	3950	+ 2	0.05	6.6 R	24.63	26	7	40	29.57
" "	11	126	3954	+ 6	0.15	14.0 R	24.56	26	7	40	29.57
" "	12	127	3498	+450	11.40	38.4 L	25.7	26	7	38	29.57
" "	13	126	3930	— 18	0.45	14.4 R	23.6	8	7	38	29.57
Mean (neg. No. 12)			3948				24.37				

Remarks—In round No. 12, January 22nd, the projectile was defective. Its flight was unsteady.

IX.

FIFTEEN-INCH FULL CALIBER PROJECTILE.

Initial pressure 1000 lbs. per square inch.
Elevation above horizontal 15°; above the target 15° 15′.
Valve setting—May 7, No. 9, 300. May 7, No. 1, 400. April 21, 400.

Date.	Number.	Loss of pressure. lbs.	Range. yards.	Range error. yards.	Range error. per cent.	Deviation. yards.	Time of flight. sec.	Velocity of wind. f.s.	Direction of wind.	Thermometer. Fah.	Barometer.
May 7.	9	204	1493	+ 22	1.50	7.2 L	8.87	11 on range 10 at gun	1	55°	29.90
April 21.	8	134	1455	— 16	1.08	0.4 R	8.77	23 at gun 26 on range	11½	47	30.27
" "	9	134	1354	—117	7.95	91.4 L	8.65	21 at gun 26 on range	11½	47	30.27
May 7.	1	117	1464	— 7	0.48	7.6 R	8.64	13 at gun 7 on range	1	55	29.90
Mean (neglecting No. 9 of April 21)			1471								

Remarks—In the 9th round of April 21st, one of the wings was detached from the projectile as it left the muzzle, causing it to fly unsteadily.

X.

FIFTEEN-INCH FULL CALIBER PROJECTILE.

Initial pressure 1000 lbs. per square inch.

Elevation 25° above horizontal. 25° 10′ above the target.

Valve setting May 7, June 2 and June 3, 300. February 19, February 26 and March 5, 400.

Date.	Number.	Loss of pressure. lbs.	Range. yards.	Range error. yards.	Range error. per cent.	Deviation. yards.	Time of flight. sec.	Velocity of wind. f.s.	Direction of wind.	Thermometer. Fah.	Barometer.
May 7.	6	198	2245	+ 3	0.13	10.4 L	14.44	15 at gun 10 on range	1	55°	29.90
" "	7	199	2009	. . .	. . .	18.6 L	15.10	16 at gun 9 on range	1	55	29.90
" "	8	205	2246	+ 4	0.18	12.2 L	14.55	12 at gun 10 on range	1	55	29.90
June 2.	4	200	2270	+28	1.24	2.6 R	14.50	2	6	70	29.94
" "	5	199	2110	. . .	. . .	11.6 R	15.10	2	6	70	29.94
" "	6	204	2210	—32	1.47	0.3 L	14.16	2	6	70	29.94
June 3.	1	210	2069	. . .	. . .	25.4 R	13.75	15	1	59	. . .
Feb. 19.	1	167	1767	. . .	. . .	18.0 R	14.5?	11	11	35	30.49
Feb. 26.	1	150	2229	—13	0.59	19.2 L	14.52	8	$1\frac{1}{2}$	44	30.01
Mch. 5.	1	150	2227	—15	0.67	1.0 R	14.50	35	6	55	30.28
" "	2	150	2264	+22	0.98	3.4 L	14.55	37	6	55	30.28
" "	3	152	2242	0	0	0.6 L	14.50	35	6	55	30.28
		Mean	2242			Mean	14.46				

Remarks—All of these projectiles were defective in that the wings were not securely fastened, frequently being broken off by the blast of the air as they left the muzzle. Round No. 1 of February 19, two wings came off at the muzzle.

Round No. 7 of May 7, round No. 5 of June 2, and round No. 1 of June 3, had very unsteady flights, probably due to the same cause. These four rounds have been omitted in striking the average. Most of the others had quite steady flights.

XI.

FIFTEEN-INCH FULL CALIBER PROJECTILE.

Initial pressure 1000 lbs. per square inch.
Elevation 30° above horizontal. 34° 9′ above the target..
Valve setting 450.

Date.	Number.	Loss of pressure. lbs.	Range. yards.	Range error. yards.	Range error. per cent.	Deviation. yards.	Time of flight. sec.	Velocity of wind. f.s.	Direction of wind.	Thermometer. Fah.	Barometer.
January 20.	10	144	2445	. . .	. . .	19.0 R	17.53	30	4	40°	30.04
" "	11	144	2541	. . .	. . .	18.0 L	16.69	25	4	40	30.04
		Mean	2493								

Remarks—Slightly unsteady flight.

XII.

FIFTEEN-INCH FULL CALIBER PROJECTILE.

Initial pressure 1000 lbs. per square inch.
Elevation 34° above horizontal. 34° 8′ above the target.
Valve setting for rounds 4 and 5—300.
Valve setting for rounds 2 and 3—400.

Date.	Number.	Loss of pressure. lbs.	Range. yards.	Range error. yards.	Range error. per cent.	Deviation. yards.	Time of flight. sec.	Velocity of wind. f.s.	Direction of wind.	Thermometer. Fah.	Barometer.
May 7.	4	197	2617	—21	0.8	27.6 L	18.71	9 on range 15 at gun	1	55°	29.90
" "	5	199	2659	+21	0.8	12. L	18.86	11 on range 15 at gun	1	55	29.90
" "	2	118	2448	. . .	. . .	70.4 L	19.46	9 on range 15 at gun	1	55	29.90
" "	3	117	2127	. . .	. . .	8.2 L	19.35	10 on range 11 at gun	1	55	29.90
		Mean	2638				18.73				

Rounds No. 2 and 3 the projectiles had very unsteady flights; these have been neglected in striking the average.

XIII.

EIGHT-INCH SUB-CALIBER PROJECTILE.

Table of variable "valve settings."
Initial pressure 1000 lbs. per square inch.

Elevation.	Valve setting.	Date.	Number.	Loss of pressure. lbs.	Range. yards.	Range error. yards.	Range error. per cent.	Deviation. yards.	Time of flight. sec.	Velocity of wind. f.s.	Direction of wind.	Thermometer. Fah.	Barometer.
15° (H) 15° 8′ (T)	600	Jan. 20.	4	75	2743	+10	0.36	8.4 L	12.25	15	5	40°	29.89
			5	73	2740	+ 7	0.25	5.4 L	12.35	15	5	40	29.89
			6	74	2715	—18	0.66	9.0 L	12.24	22	5	40	29.89
			Mean		2733				12.28				
15° 15° 15′	800	Jan. 20.	7	29	1432	—17	1.17	1.2 L	8.73	22	4	40	29.89
			8	28	1467	+18	1.24	0.2 L	8.74	25	4	40	29.89
			9	28	1203	. . .	. .	0.4 L	8.19	26	4	40	29.89
					1449				8.73½				
20° 20° 9′	600	April 21.	1	47	2435			2.8 L	14.2	16 on range 25 at gun.	11½	47	30.27
25° 25° 7′	600		2	49	3023			12.6 L	17.45	15 on range 22 at gun.	11½	47	30.27
34° 34° 6′	600		3	52	3573			42.4 L	22.73	16 on range 26 at gun.	11½	47	30.27
34° 34° 12′	800		4	19	1808			13.2 L	15.6	15 on range 26 at gun.	11½	47	30.27
	800		5	19	1232			0.6 L	14.5	15 on range 27 at gun.	11½	47	30.27
				Mean	1808				15.6				

Remarks—Rounds No. 9, January 20th, and No. 5, April 21st, gas checks failed to detach, very unsteady flight in consequence. These are neglected in striking an average.

H and T refer to elevation above horizontal and target respectively.

XIV.

TEN-INCH SUB-CALIBER PROJECTILE.

Table of variable "valve settings."
Initial pressure 1000 lbs. per square inch.

Elevation.	Valve setting.	Date.	Number.	Loss of pressure. lbs.	Range. yards.	Range error. yards.	Range error. per cent.	Deviation. yards.	Time of flight. sec.	Velocity of wind. f.s.	Direction of wind.	Thermometer. Fah.	Barometer.
15° (H) 15° 12′ (T)	600	Jan. 22.	4	73	1789	—11	0.61	0.8 L	9.8	26	7½	41°	29.57
			5	70	1807	+ 7	0.39	5.6 L	9.87	28	7½	41	29.57
			6	68	1803	+ 3	0.16	8.4 L	9.82	28	7½	41	29.57
			Mean	70	1800				9.83				
15° 15° 22′	700	Jan. 22.	7	34	1014	— 1	0.14	0.6 R	7.15	25	7	40	29.57
			8	33	1017	+ 2	0.14	0.8 L	7.18	25	7	40	29.57
			Mean	33½	1015½				7.16½				
25° 25° 10′	600	April 21.	6	50	2133	+ 5	0.23	21.6 L	15 49	35 on range 25 at gun.	11½	47	30.27
			7	51	2097	—31	1.46	17.2 L	15.60	28 on range 24 at gun.	11½	47	30.27
			10	48	2155	+27	1.27	6.8 L	14.57	34 on range 23 at gun.	11½	48	30.27
			Mean	50	2144				15.22				
34° 34° 8′	600	April 21.	11	51	2239	. .	. .	40.8 L	20.73	32 on range 24 at gun.	11½	48	30.27
			12	52	2641	0	0	17.6 L	19.52	33 on range 28 at gun	11½	48	30.27
			Mean	51½	2641				19.52				

Rounds No. 7 and 11, April 21, projectile had very unsteady flight; these have been neglected in striking average.

XV.

RANGE TABLE.

(Uncorrected for wind, thermometer and barometer.)

Elevation of the gun above horizontal.	EIGHT-INCH SUB-CALIBER.		TEN-INCH SUB-CALIBER.		FIFTEEN-INCH FULL CALIBER.	
	Elevation above the target.	Mean range. yards.	Elevation above the target.	Mean range. yards.	Elevation above the target.	Mean range. yards.
15°	15° 8′	2931	15° 10′	2295	15° 15′	1471
20	20 6	3742	20 8	2922	. . .	. . .
25	25 5	4290	25 7	3272 fog.	25 10	2242
30	. . .	. . .	. . .	. . .	30 9	2493
34	34 5	4994	34 6	3948	34 8	2638

RANGE TABLES.

For constant elevation and varying "Loss of Pressure." (The ranges are uncorrected for wind, thermometer or barometer.)

XVI. XVII.

EIGHT-INCH SUB-CALIBER PROJECTILE.

15° ELEVATION.		34° ELEVATION.	
Loss of pressure.	Range, yds.	Loss of pressure.	Range, yds.
136	2931	124	4994
74	2733	52	3573
28	1449	19	1808

XVIII.

TEN-INCH SUB-CALIBER PROJECTILE.

15° ELEVATION.	
Loss of pressure.	Range, yds.
130	2295
70	1800
33½	1015

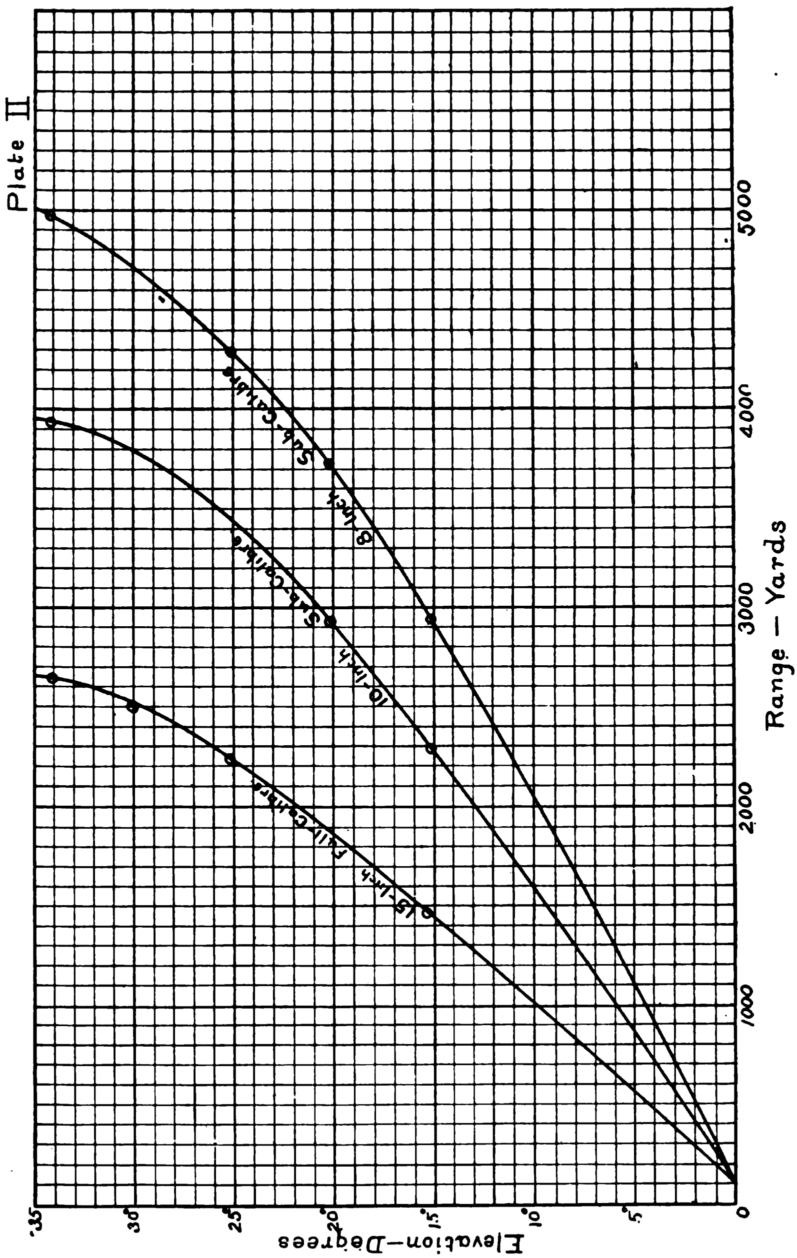


Plate II
8-inch Sub-Calibre
10-inch Sub-Calibre
15-inch Full-Calibre
5000
4000
3000
2000
1000
0
Range — Yards
35°
30°
25°
20°
15°
10°
5°
Elevation—Degrees

As stated at the beginning of this article, the object of the experiments and test of the gun, was first, to become familiar with the new weapon; second, to test its accuracy and at the same time construct a range table for the different sizes of projectiles fired under varying conditions of elevation and valve setting. Incidently many peculiar features of both gun and projectiles were brought out. The preceding tables show how well the object was attained.

One of the most prominent features of the tests and the one that has caused the most comment, is the great accuracy of "fire" which the gun possesses. This is due to the fact that exactly the same amount of energy can be imparted to the projectile at each discharge, hence if the projectiles have a steady flight through the air they must go exactly the same distance each time, conditions of the atmosphere remaining the same. The energy imparted to the projectile is determined by two important factors, the initial pressure in the bore and the quantity of air used at each discharge. The first of these is practically invariable and it can be measured, with the guages used, to one-tenth of one per cent. The second factor depends upon the action of the valve which controls the escape of air into the barrel from the gun reservoir. The accuracy with which this valve measures the quantity of air used at each discharge is shown by the loss of pressure in the gun reservoir. Since we know the initial pressure to be constant we can judge of the amount of energy imparted to the projectile by the loss of pressure. If the loss of pressure is the same at each discharge we shall know that the projectiles have had imparted to them the same amount of energy and consequently have left the gun with the same initial velocity. We are here neglecting any variations of friction and other very slight disturbing effects, because we believe them too small to be appreciable. The design and construction of this valve which automatically measures the air used at each discharge was the most difficult engineering problem encountered in the design of the gun. Many valves were constructed and tried, and many more were designed on paper before a satisfactory one was obtained. A detailed account of the history and evolution of the present valve through all its stages, would fill a large volume. Suffice it to say the present valve is the result of eight years of hard labor. It is not perfect, for there is no such thing as perfection, but it has given excellent results.

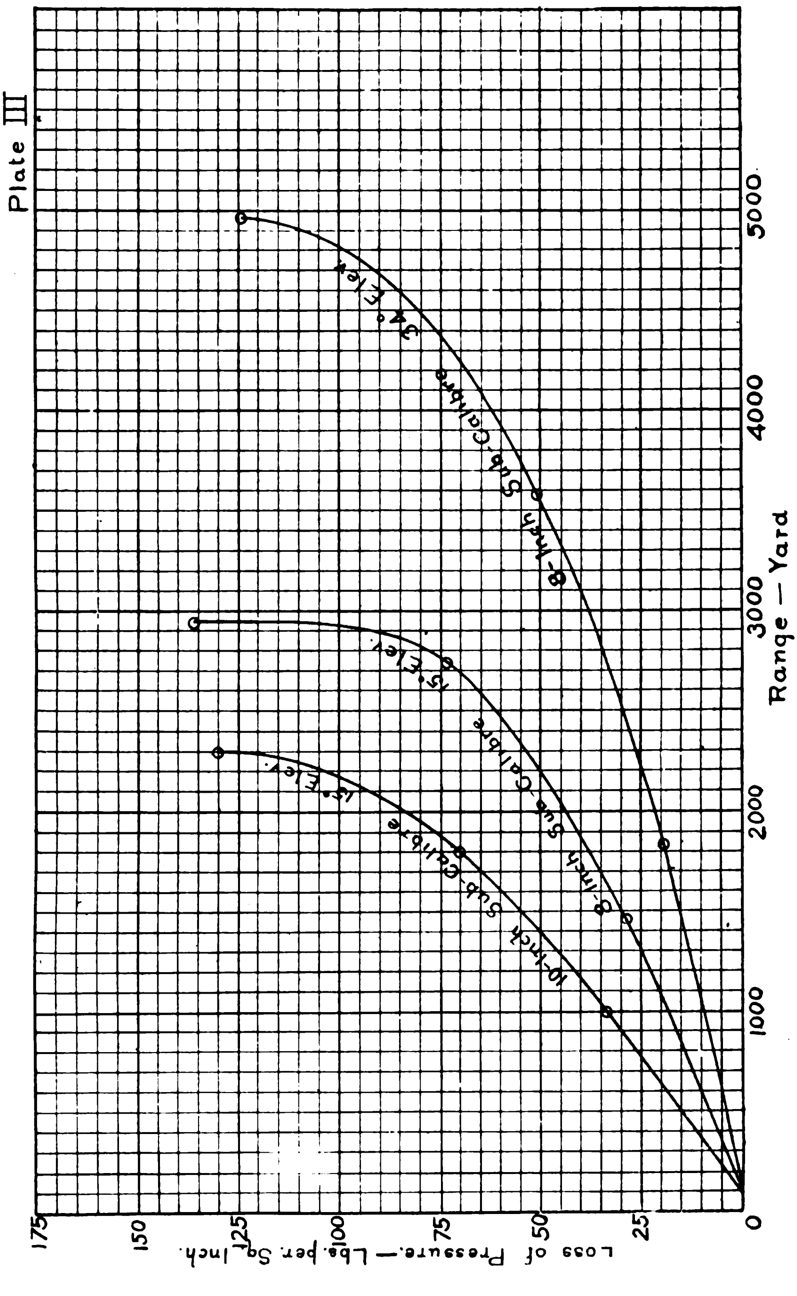


Plate III
8-Inch Sub-Calibre 34° Elev.
8-Inch Sub-Calibre 15° Elev.
10-Inch Sub-Calibre 15° Elev.
0
1000
2000
3000
4000
5000
Range — Yard
0
25
50
75
100
125
150
175
Loss of Pressure. — Lbs. per Sq. Inch.

It has already been explained how the "valve setting controls the loss of pressure" given in the third column of each table. A glance at the tables will show that the "loss of pressure" was somewhat different on different days for the same valve setting. This was found to be due to three causes, viz: first, variation of temperature; second, wear in the moving parts of the valve mechanism; and third, accidental disturbances such as dirt lodging in the regulating orifice of the valve. The first and second are the principal and most important causes. The experiments were begun in the middle of a very cold winter and continued until the following June when the weather was quite warm, thus subjecting the gun to extreme changes of temperature. By a more careful examination of the tables, it will be seen that, as a rule, the lower the temperature, the larger the loss of pressure for the same "valve setting" and *vice versa;* furthermore, it will be observed that the later the date of firing the smaller the "loss of pressure". In addition to this there is occasionally, what may be termed an accidental variation, but these do not occur frequently to any marked degree so need hardly be considered. If these changes occurred irregularly they would seriously affect the accuracy of the gun when using a short cut-off or small loss of pressure, but they are quite regular; the losses of pressure are very uniform on any given day, only varying on different days. By simply making an air-shot, it is possible to determine the losses of pressure corresponding to the "valve settings" for that particular day, and thus to adjust the ranges.

The only practical method of determining accuracy is to fire a series of shots as nearly as possible under the same conditions and note the ranges and deviations. To do this all the rounds must be fired on the same day and a day should be selected when there is little or no wind. Not less than five rounds should be fired in order to eliminate any accidental errors such as a defective projectile. So far as practicable these conditions were adhered to in the Shoeburyness tests.

Let us examine some of the tables and see what results were obtained. Table II gives the record of five rounds of 8-inch sub-calibers, each having a capacity for 100 pounds of high explosives and weighing 337 lbs. 10 oz. The mean range was 3644 yards or $2\frac{7}{100}$ miles. All five projectiles hit a horizontal rectangle 7 yards long by $5\frac{4}{10}$ yards wide. Two had exactly the same range and a difference in deviation from the line of fire of only $1\frac{4}{10}$ yards. The greatest variation in range from the mean is 4

yards or $\frac{11}{100}$ of one per cent. It must be remembered that this firing was over land, not over water so that the records are absolutely trustworthy. It would be difficult to make a better record with a powder gun.

Referring to Table VIII five rounds of 10-inch sub-caliber projectiles were fired on January 22, each having a capacity for 200 pounds of high explosives and weighing 529 lbs. 8½ oz. One projectile was defective. Its flight was unsteady and in consequence it fell 450 yards short. The mean range of the remaining shots was 3948 yards or $2\frac{24}{100}$ miles. They all hit a rectangle 28 yards long by $15\frac{2}{10}$ yards wide. The wind suddenly died out after the fourth round causing the fifth round to fall short. Had it not been for this the rectangle would have been much smaller.

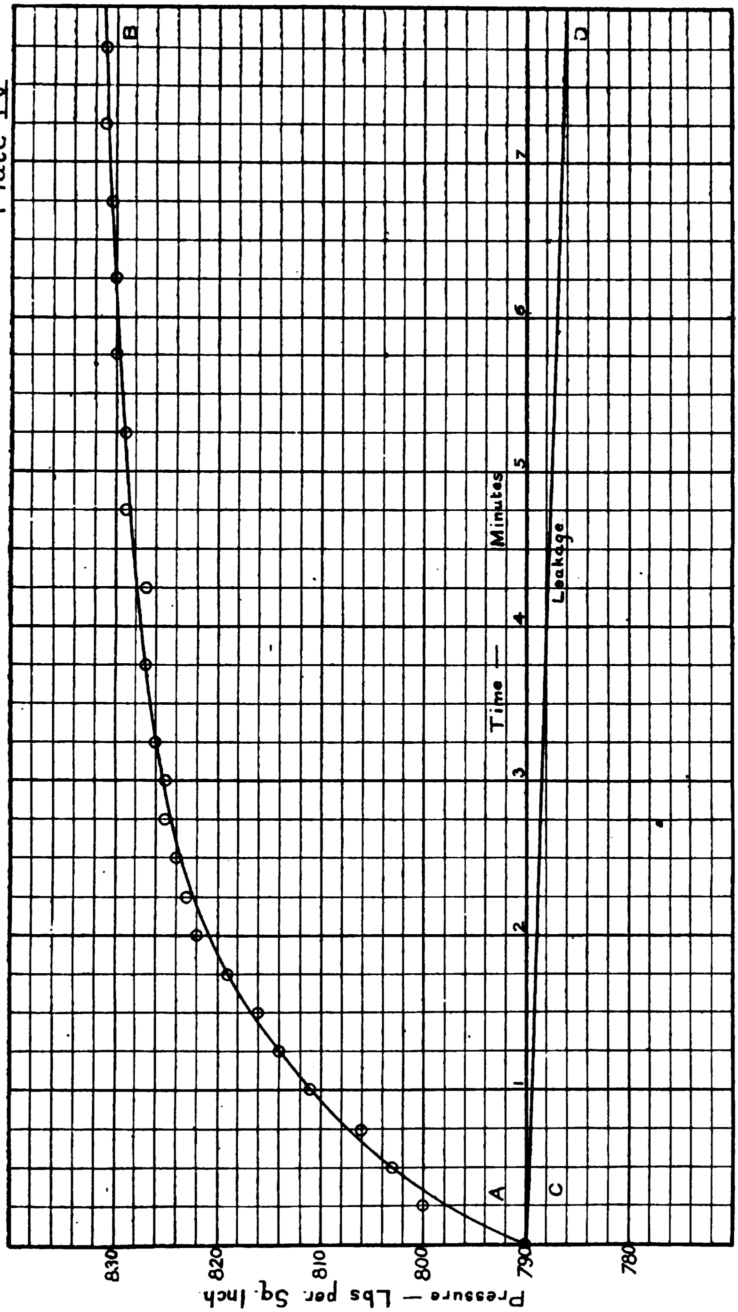
On Plate V all of the more important shots have been plotted showing their relative position of striking on a horizontal plane. The large circles surrounding each shot show the area of destruction to a first-class armored vessel computed by the formulæ of General Abbot, which formulæ are based on actual experiments with submarine explosions. Had the "firing" been at a vessel and any portion of her hull been included by an arc represented by one of these circles, she would have been destroyed.

Steadiness of flight is very essential to accuracy with the lighter projectiles but it is not of so great importance with the very heavy full-calibers weighing about 1000 lbs. because their velocity is low and they possess so much inertia that the air has less resisting effect upon them.

Most of the shots deviate to the left of the assumed line of fire even when the wind was blowing quite strongly from the left. This may be due to natural drift of the projectiles in that direction or it may be due to the sight not having been adjusted exactly parallel to the axis of the bore of the gun. The projectiles rotate as they move through the air, in a clockwise direction when looking at their base. The direction of rotation is the same as with rifle projectiles, but rifle projectiles drift to the right. In searching for an explanation of this difference in direction of drift we would remark that in the case of one the resistance of the air imparts the rotation while with the other it retards it. This may or may not be the true explanation.

Experiments with varying losses of pressure and constant elevation show that there is little or on increase of range obtained by increasing the loss of pressure beyond about 125 lbs. In other words it is only a waste of air to lose more than

Plate IV



Recovery of Pressure in the Firing Reservoir by Absorption of Heat.

125 lbs. at each discharge. Or, any variation in the loss of pressure above 125 lbs. causes very little or no variation in the range. This is shown by the Tables XVI, XVII, XVIII and by the character of the curves on Plate III. Hence, in comparing the tables when the loss of pressure exceeds 125 lbs. the energy imparted to the projectiles can be considered maximum and constant.

A loss of pressure of 125 lbs. is given by closing the valve when the projectile has moved 19.61 feet along the bore or 41% of the length of the bore. We should expect some increase of range from a later cut-off than this but the the reason that we do not get it is probably due to the greater weight of air that must be accelerated and the increase in friction along the bore and in the passages leading from the gun reservoir.

Table XV gives a summary of the tests with full cut-off and varying elevations in a convenient form for interpolation and the same is shown by means of characteristic curves on Plate II. The curves for the three sizes of projectiles are exactly similar in form. The ratio of ranges of the 8-inch to the 10-inch sub-calibers is 1.27. The ratio of the 15-inch to the 10-inch is 0.66; and the ratio of the 8-inch to the 15-inch is 1.91.

The method of loading and maneuvering the gun, admits of firing with considerable rapidity, which is a very valuable feature of the system and one that can hardly be over-estimated. The men had had very little drill in loading but on one occasion five rounds of 8-inch sub-calibers were loaded and discharged in 11 minutes 33 seconds, the gun being elevated and laid on the target for each shot; in fact these five rounds were a part of the test for range and accuracy. Had it been simply a test for speed of loading twice this number of rounds could have been discharged within the same time. When compared with powder guns of the same or much smaller caliber, this is a very creditable showing. The large full caliber projectiles weighing 1000 lbs. can be loaded nearly if not quite as rapidly as the smaller sub-calibers.

Part 3 of the program states that two shells of each caliber shall be fired at an earth parapet at 1000 yards and note made of the penetration. This program was afterwards changed to one 8-inch and one 10-inch sub-caliber projectile. The parapet was located 592 yards from the gun and consisted of beach sand piled up and supported by wooden partitions of 1½ inch deal boards. The face towards the gun was slightly terraced and

sodded to make it as nearly vertical as possible. Two preliminary shots were fired across the sands to determine the necessary elevation to hit the parapet at the desired point, no previous shots having been made below 15 degrees. The firing took place on February 27th. The first round was with an 8-inch sub-caliber projectile and it penetrated 45 feet. The elevation of the gun was 2° 25′ above the bull's-eye. An attempt was made to measure the velocity of the projectile by placing screens 30 feet apart just in front of the parapet. The projectile pierced the first screen and passed under the second cutting one of the lead wires; consequently one of the chronographs failed to record, but the other gave a velocity of 778 feet per second. The muzzle velocity was probably more than 800 feet per second. Several other attempts were made to measure the velocities, but this is the only record obtained.

The second round was with a 10-inch sub-caliber projectile and it penetrated into the parapet 47 feet piercing one of the wooden partitions. The elevation of the gun was 3° 18′ above the bull's-eye. Neither projectile deviated from the line of fire after entering the sand and neither were injured with the exception of having their wings stripped off. Scratches on the bodies of the shells plainly showed their rotation. The ogival heads were polished and scratched from the point backward nearly to the shoulder, but from this point to some distance backward on the tube the paint was not scratched, showing plainly where the stream lines left the head and returned again to the body.

This was the most interesting and instructive experiment made at Shoeburyness. When we consider the low velocity of these projectiles, the penetration was remarkable and it emphasizes the proportionate inefficiency of high velocities. Had these projectiles been charged with 100 and 200 pounds of dynamite, their destructive effect buried at this depth in the earth would have been terrible.

It is a valuable illustration of the efficiency of the pneumatic torpedo system when used in bombarding cities or fortified positions. Who can tell the destruction that would be wrought by one of these shells or torpedoes, discharged from a gun mounted on board a vessel, into earthworks used so much for modern fortifications and against which shots from powder guns have so little effect.

At each discharge of the gun, the air in the gun reservoir is cooled by its own expansion. Having fallen in temperature, it

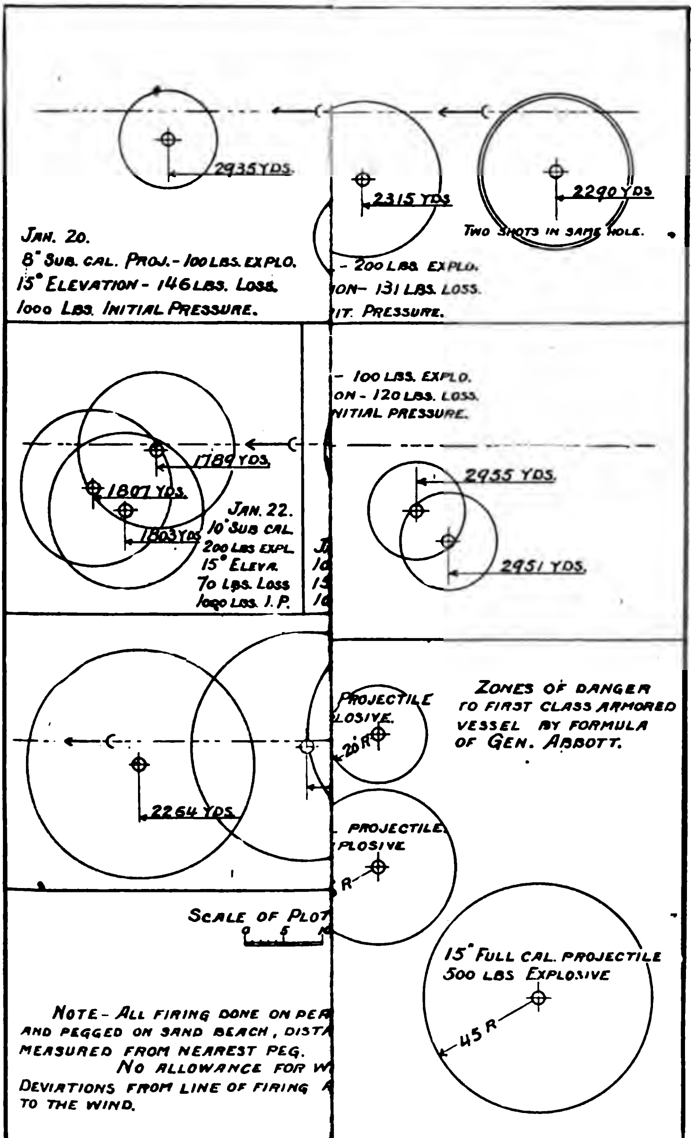
immediately begin to absorb heat from the walls of the reservoir and this heat causes the pressure to rise gradually for several minutes after discharge. This increase of pressure is shown by a curve A B on Plate IV. The gun was leaking a little at the time the readings were taken and this leakage is shown by a second curve C. D.

This increase in pressure is a slight increase of stored energy, but it has little practical effect upon the gun. I mention it here because it is interesting from a scientific or engineering standpoint.

After concluding the above tests the gun was dismounted and removed to another place, where experiments could be carried on with high explosives.

B. C. Batcheller, S. B.

Plotting of experimental long. 1891. PLATE V.



SEA-COAST DEFENSES AND THE ORGANIZATION OF OUR SEA-COAST ARTILLERY FORCES.

DISCUSSION.

A. E. ORR, *President of the New York Produce Exchange and of the New York Chamber of Commerce.*—In view of the recent discussions of the Monroe Doctrine, the following extract from a letter written by the late Samuel J. Tilden to Mr. Carlisle is of interest:

"A million of soldiers with the best equipment on the heights surrounding the harbor of New York in our present state of preparation, or rather in our total want of preparation, would be powerless to resist a small squadron of war steamers.

"This state of things is discreditable to our foresight and to our prudence. The best guarantee against aggression, the best assurance that our diplomacy will be successful and pacific, and that our rights and honor will be respected by other nations, is in their knowledge that we are in a situation to vindicate our reputation and interests. While we may ever be deficient in our means of offense, we can not afford to be defenseless. The notoriety of the fact that we have neglected the ordinary precautions of defense invites want of consideration in our diplomacy, injustice, arrogance and insult at the hands of foreign nations.

"It is now more than sixty years since we announced to the world that we should resist any attempts from whatever quarter they might come to make any new colonizations in any part of the American continent; and while we should respect the *status quo* we should protect the people of the different nations inhabiting this continent from every attempt to subject them to the dominion of any European power, or to interfere with their undisturbed rights of self-government. This announcement was formally made by President Monroe, after consultation with Mr. Madison and Mr. Jefferson. It was formulated by John Quincy Adams. Our government has firmly adhered to the Monroe Doctrine, and even so late as 1865 it warned Napoleon out of Mexico. It is impossible to foresee in the recent scramble of the European powers for acquisition of colonies how soon an occasion may arise for our putting in practice the Monroe Doctrine. It is clear that there ought to be some relation between our assertion of that doctrine and our preparation to maintain it."

These words are as appropriate to-day as if they had been written with a foreknowledge of the events that have taken place within the past few weeks.

Whatever our individual views may be regarding the Monroe Doctrine, it is of the most vital moment to us as a nation that we should have our coasts adequately defended. I am pleased to see that Colonel Sanger's article not only calls attention to the patriotic reasons, but also emphasizes the economical and business arguments in favor of spending sufficient money for forts and guns to defend us from attack. No true American wants to see his country engaged in war. It is equally true that no one wants to see his property destroyed by fire. In order to prevent the losses which would result from an unchecked conflagration we cheerfully, as General Abbot, of the Engineers, has pointed out, pay taxes to maintain fire departments and premiums for insurance polices to indemnify us against loss. The same logic should make us be willing, as a nation, to spend the money necessary to protect our sea-coast against the attacks of foreign foes, especially as such preparation would lessen the burden and horrors of war if it should ever come upon us. Indeed, I might go further and say that as our principal and very attractive vulnerable point is the defenseless condition of our seaboard cities —a fact so patent that it needs little or no illustration to demonstrate—so their adequate protection against maritime attack would, in my judgment, be one of the most effective safe-guards we could possibly have towards insuring to the United States a continuance of the blessings of peace.

I do not feel that I should attempt to speak authoritatively in regard to the proposed plan for the organization of the forces to do duty in our harbor forts. It seems to me, however, very desirable, as Colonel Sanger recommends, that these forces should be organized under one general plan, so as to insure harmonious and effective action. I am favorably impressed with his suggestion that in order to accomplish this the plan for enrollment and organization of the sea-coast forces should be formulated under authority of Congress, especially as he makes it plain that such a plan would not infringe upon the prerogatives of the States, or lead to the evils of over-centralization of the force.

His suggestion, on page 34, that a commission should be appointed by Congress to consider the entire question and formulate a plan commends itself to me as being most wise. Such a treatment of the question, especially if the commission contained, as

it doubtless would, one or more representative men in civil life, would, I think, strengthen in the minds of the people at large the conviction that the plan proposed was in the interest of all, and not of any class.

PETER C. HAINS, *Colonel of Engineers, United States Army.*—The article of Colonel Sanger is both timely and suggestive. For nearly a quarter of a century the attention of Congress and the people has been called to the utter inefficiency of our coast defenses. The danger of leaving an enormous amount of wealth along the seaboard exposed to destruction in the event of war, the comparatively small sum needed to secure perfect protection, and the utter impossibility of making adequate provision for protection after danger threatens, have all been stated and re-stated, written up and talked threadbare. The men who have been doing this patriotic duty (for it will be conceded to be such) have grown grey and tired. Their work, however, has borne some fruit. Like the first fruit in a newly planted orchard, the crop is scanty but it promises well in the near future. From present indications it looks as though Congress and the people are now prepared to take up the subject of our coast defenses in earnest and provide the guns and emplacements for a system that will insure us against insult from any foreign power whatever.

This however is only the first step.

It is not enough to provide guns and emplacements even though they be of the most modern construction. The guns would be of little use, unless they be manned and worked by an efficient sea-coast artillery organization, thoroughly trained for that work. That the existing artillery organization is not adapted to the purpose is too manifest for comment. There may be differences of opinion as to the best form of a proper organization, but we beieve that few artillery officers, if any, would claim that its present organization is suited to modern conditions. The service of a modern 12″ rifle is by no means similar to that of an old 15″ smooth-bore, the largest ordnance in common use up to the advent of modern steel rifles. The 15″ gun needed only well drilled men to load and aim the piece rapidly. The service was simple, the aiming was seldom or never done at a range exceeding 2500 yards and required no delicate range-finding instruments.

Now the 12″ rifle requires the use of powerful machinery for raising and lowering it, to and from the firing position; the people serving it must understand the construction and use of

steam boilers, hydraulic rams, electrical appliances, etc. A leaky valve may render a battery of such guns temporarily useless if the trouble cannot be quickly located, and when located, a knowledge of the best means of repairing it is essential. If the guns be mounted in turrets the mechanism is still more complicated and calls for still more technical knowledge for their efficient use. The skillful use of the the range-finder requires knowledge of mathematics, that of the electrical apparatus some knowledge of electricity, that of the hydraulic ram and steam engine, a knowledge of mechanical engineering. In other words every artillery officer and a certain proportion of non-commissioned officers and men should be expert in mechanical engineering, in electricity and in surveying.

It would seem that the first thing to be done is to have the artillery branch of the army increased and organized on a proper and permanent basis for the defense of the coasts. How that can best be done is not a question that it is proposed to consider now. Officers of the artillery should try to reach some common ground on which all can stand and let the details be settled as best they may. Differences of opinion as to details are to be expected, and their expression should be encouraged. But the general principles that would serve as a guide to congressional action and on which artillery officers could unite, ought to be agreed on.

We all know how difficult it is to get any legislation from Congress for the betterment of any branch of the army, but the task is beset with insurmountable difficulties when there is great diversity of opinion among officers themselves as to what should be done. If they cannot agree on what is best, how can the average layman be expected to solve the problem?

We have in the artillery branch of our army as fine a body of officers as can be found in any army in the world. There is the most excellent material available, but the existing organization is not suited to the modern requirements of sea-coast defense. That the artillery as an arm will give a good account of itself if called on in an emergency goes without saying, but it will be in spite of a poor organization.

The auxiliary state organizations for helping to man our coast defenses should be modeled on that of the permanent national organization, whatever that may be. As it is by no means probable that the latter will ever be large enough, to meet the emergencies of war, reliance will have to be placed on state organizations to fill up the deficiencies. To secure harmonious

action, the latter must be organized on the same plan as the former. Such organizations would, it is believed, become popular in the vicinity of large cities where permanent sea-coast defenses are constructed, and little or no difficulty would be experienced in securing plenty of the best material when needed.

GENERAL GEORGE W. WINGATE, *President of the National Guard Association of the United States.*—Colonel Sanger is entitled to great credit for his lucid statement of the condition of our sea-coast defenses. That this does not exaggerate the national needs, is known to every thinking man.

That the United States is not only in such a condition as to defenses that it may be insulted with impunity by any one of many nations far inferior to it in strength, but that it is liable at any time to be exposed to the most serious disaster from its utter inability to protect itself, is self evident. That some plan should be adopted and at once, to enable at least our principal cities to be defended, is equally so. The development, however, of a plan which will be practicable and at the same time efficient, is a very difficult matter.

My own knowledge of heavy artillery matters is so slight that I feel diffident in offering any suggestions. In particular, I feel myself embarrassed from not knowing how long it takes "to make an artillerist." Colonel Sanger states in his paper that it is conceded by all authorities that at least a year is required for this purpose. To turn out a first class "all round man" who would have at his fingers' ends all the details of the art, would seem to require even more than that time. But on the other hand, it would also seem that intelligent men could be taught all that the ordinary artilleryman needs to know in very much less time. I myself have seen National Guardsmen in service, taught in less than a week, to handle a battery of field pieces in an earth work so that they could compare very creditably with the volunteer battery that formerly manned them. I have also seen a Light Battery learn its duties while on the march, and in a very few days after its enlistment acquit itself with credit in a brisk artillery fight, having of course the benefit of an experienced officer to supervise the cutting of the fuses and the elevations of the pieces.

Officers who served in the heavy artillery regiments that garrisoned the forts around Washington during the Civil War, state that three weeks was ample to train the men to handle the heavy guns with which those forts were armed.

It is true, unquestionably, that modern guns are more complicated in their carriages, but is their actual manipulation so much more so that what is required to be done by the details that manage them, cannot be picked up by an intelligent man in a few weeks? In this of course I except the gunnery.

It is self-evident that this is a matter which requires a good deal of study and more practice, both of which take time. So far as the aiming of the gun is concerned, this can be done by any soldier who knows how to shoot a rifle, provided that he has an officer who will give him the necessary wind allowance and elevation for distance, and direction as to his fuses in the same way that the members of a rifle team are directed by their coach in a match. To secure the necessary direction upon these points it is indispensable that the officers and non-commissioned officers of any artillery organization must be so selected and trained that they can make the fire accurate. But why cannot this be obtained by having a few expert gunners, the rest of the gun detachment merely doing as they are told? Outside the matter of range-finding (which while a very difficult matter will mostly be ascertained by the use of instruments) I am somewhat inclined to believe that men who have been trained to shoot a rifle at the longer ranges, ought to be able to learn how to fire a heavy gun accurately, in a much shorter time than Colonel Sanger thinks to be necessary. Thus in the artillery competitions among the English volunteer artillery, to which I shall hereafter allude, the competing teams from the volunteers appear, from the reports of the matches, not only to fire with as much accuracy as those from the regulars, but in the "repository competitions" which involve the dismounting, moving and mounting of a heavy gun are often the winners.

From the accounts of the practice cruises of the Naval Reserve, it would appear that although their opportunities for practice are very small, yet that their firing with the guns upon our cruisers is fairly good.

The sources from which an artillery force is to be derived, consist of the army, the National Guard and a supplementary force.

The necessity of a large addition of artillerists to the army goes without saying. These men should be of as high a grade of intelligence as is possible to be obtained; fully as high as is the case with the engineers. They ought to be carefully trained as gunners and should constitute the officers and non-commissioned officers, who will control and supervise the instruction of

whatever auxiliary forces may be organized. In other words, they are to be the *scientific artillerists*, while the others supply the men and the muscle needed to do the work.

I do not think that very much aid can be expected from the National Guard of the States, in the way of an additional artillery force. These, as a rule, have all that they can do to learn their business as infantry, within the time that they are able to spare from their business. To add to this any considerable amount of artillery duty, even assuming that the states would do so, would be very apt to make them poorer infantry men without becoming efficient artillerists. Still, by judicious management, some of them might be taught a good deal in this direction, provided that it should always be borne in mind that while National Guardsmen are willing to give their nights to military matters, they cannot afford to spare their days, (which are occupied by their business). This is particularly the case in regard to anything which calls upon them to absent themselves from their business for any length of time.

A week in camp every other year, is felt in New York to be all that the officers and men can be asked to sacrifice, in addition to their other military duties and in the days they have to spend upon the rifle range. In some other states they are able to get a week in the camp every year. This is little enough to get the organizations into good condition as infantrymen, but is all that can be had. There is always a difficulty in securing good officers.

It seems to me that the wise method to adopt in regard to instructing the National Guard, in the use of artillery, if it should be undertaken, would be that in each large city, a heavy gun should be issued to the government, and mounted either in one of the State arsenals or one of the armories, so that it could be used by detachments of the National Guard during the evenings. If a real gun could not be spared, (as would probably be the case) a dummy might be constructed with such arrangements as to afford to the squad using it, the same resistance that is found in handling the gun itself. I have seen such a gun mounted in the armories of one of the volunteer organizations in London. This gun should be provided with a sub-caliber tube of small bore in such a way, that it could be fired with a 22-caliber cartridge at a miniature target representing ships at different ranges. The target itself should be arranged upon an arm which could be swung in different directions or arranged with a wire and windlass, so that it could be moved to imitate the appearance of ships approaching at different angles, and at different distances.

In this way the men under the supervision of an army officer could be practically instructed in aiming and firing as in the service, and the drill would be much more interesting than would otherwise be the case.

The officers of the command, undergoing this instruction, should be first drilled by regular officers and lectures given them instructing them on the simpler points of the service. Then the non-commissioned officers could be instructed and they in turn would instruct the companies. It must, however, be always borne in mind, that while a certain percentage of the officers are enthusiastic soldiers and students, most of them learn their duties by doing them, and beyond the drill book, cannot be got to study but a very little. I do not therefore think it is practicable to make any considerable number of them what would be called good artillery officers.

If it were possible to fit up one or more forts in the harbors of our large cities with an electric light, a good deal of practical instruction might be given to volunteers from the different organizations, in the actual use of the guns, upon summer evenings. Practice might also be had on Saturday afternoons during the summer, with an occasional field day, and as often as practicable, a tour of a week in the year during which the regiment did not have to go to camp. In doing this, great attention should be paid to actual firing, as the men would be a good deal interested in that, particularly those who are expert riflemen. These would consider it to be great fun, which would go to break up the monotony of mere gun drill. The duty must necessarily be largely voluntary, and unless it is made interesting it will be difficult to induce the men to attend.

In England there is a regular National Volunteer Artillery Association, which has annual competitions at the forts, in which teams from the different organizations compete, not only firing with heavy guns at stationary and moving targets, but also in "time" competitions, in mounting, dismounting and moving a heavy gun, and as above stated, they do work which compares very creditably with that of the regular artillery.

It is very probable that the light batteries and Gatling batteries of New York would be glad to undertake this instruction as an addition to their present drill, which they find somewhat limited. Perhaps, therefore, their armories might be found to be the best places in which a gun for instruction might be mounted. The signal corps might be instructed in the use of the position and range finders. If the matter is intended to be

introduced into the National Guard a short and simple manual should be prepared for the use of its officers and men, in which the necessary instruction should be "boiled down" to its simplest form; it being remembered that the officers and men cannot be expected to go deeply into a subject which is so complicated and which requires such special instruction as artillery; that they must be kept interested, and I again repeat that the true way to do this is to let them shoot all that is possible, and the more the better. I think that with artillery even more than infantry the maxim applies that "fire is everything, the rest is nothing."

I see no way in which anything of any consequence in the way of artillery can be accomplished with the National Guard, except in the case of those organizations which are stationed in proximity to fortifications. It is not practical to have troops from the interior brought down to the forts for instruction for enough time to have them learn sufficient to be of any military value. It would cost too much money and take too much time.

The only practicable method of establishing a proper artillery force would therefore seem to be that which is referred to by Colonel Sanger and Lieutenant Allen, namely, a specially enlisted force the members of which shall serve for a short time during the first year of enlistment, and who will then pass into a Reserve, provided always that this force be supplemented by a permanent force of regular and permanent artillerists, who will serve as its instructors and examples. This can only be accomplished through the action of Congress. It is out of the question to expect the states to do it.

Until the Venezuela matter arose, it would have been equally out of the question to expect any such action from Congress. For more than twenty years, the National Guard Association of the United States, (of which I have the honor to be President), has been patiently endeavoring to secure the repeal or modification of the obsolete provisions of the National Militia Law referred to by Colonel Sanger. A number of years ago the Association was fortunate enough to secure the raising of the annual appropriation for the militia from $200,000 to $400,000, but there we stopped. There has however been a great change in the public feeling upon this subject, and it would appear now as if the necessary congressional legislation might be had. It seems certain that the country is going to be given more coast defenses, and it is so clear that men must be had for these, that it seems likely that they will be granted. To attempt to make

the proposed force a portion of the militia of the several states, does not seem to me to be wise. These states have all they can do to maintain their present force. These forces would be apt to oppose a plan for the addition of an artillery organization to the National Guard of the states, as being likely to interfere with the little aid that they receive from their own state, and their opposition would be serious. Neither have any of the states any experience in organizing or handling a heavy artillery force. Every state would manage its part of any such organization in a different way, the result being a heterogeneous, disorganized, poorly officered and inefficient concern, the exact reverse of what the government needs. It may perhaps be true, that if the proposed organization was made a part of the National Guard of the different states, it might tend to remove the objection that the establishment of such a force would be too great an increase to the army. But in order to be of any military utility, it is self-evident that the new force, whether it be called National Guard or any other name, must be officered and managed by regular officers. It is utterly impossible to get National Guardsmen, who have the knowledge or the time to instruct such a force, and to attempt to do so would make the whole thing a failure. The intense jealousy which experience shows breaks out in Congress at anything that looks to giving the regular officers command over the National Guard or allows them to interfere with it in any way, is so great that there would be fully as much, if not more, opposition to a law organizing such a force if called militia, than if it were to be organized directly as a part of the army. On the other hand, in the latter case, it would be efficient and valuable, while in the former it would be neither.

The proposed force should be enlisted as regular soldiers, but only for as long a continuous period as would be sufficient to instruct the men in the first instance in their duties. How long this should be is a matter of opinion. My own is that it ought to be from six months to a year. The men should then be furloughed to report their residence from time to time, and to be annually assembled at some of the forts for a sufficient period to enable them to recall what they have previously learned, say for about a month in each year; each man being paid during his enlistment a small amount per month, so that he can be kept track of, besides full pay when on duty. In order to secure a superior class of men, the pay should be good and none should be accepted but those of intelligence and fair education. There are many young mechanics and working men to whom a few

weeks spent in the forts near our large cities, "soldiering" during the summer with good pay, would be an agreeable outing. This would be particularly the case with those whose trades are dull in the summer time. If the bill for transportation would not be too heavy, more men could be got in the winter to go to one of the southern forts, than perhaps in the summer. It must, however, be borne in mind that what are known as working men are usually as much tied down to their business as any other portion of our people. Those who have what is termed "a steady job," such as railroad men, workmen in factories or contractors, clerks, etc., cannot leave their occupations except at the utmost for a week once a year. Many others, however, drift "from job to job," and can "take off" a month whenever they desire, provided they are paid, so that they do not lose their time. The former are the men that it is desirable to secure for the artillery reserve, as they can always be found when wanted. On the other hand they are the hardest to induce to enlist.

JOHN GIBBON, *Brigadier General, United States Army (retired)*.—In my opinion there is no subject of more importance than the organization of our military forces in this country. Not because there is any prospect of war, but because an efficient organization is a wise and necessary precaution for what sooner or later must come to us.

In place of people crying out about our being perfectly unprepared for war, and the need for at once putting up stone walls on the land and iron walls on the sea, I would much prefer to see it proclaimed that we are better prepared for war to-day than we have ever been, and will be better prepared next year than we are this, because our fighting force and warlike material will be greater, and that our greatest immediate need is an efficient organization of our volunteer forces, on which the result of any war must eventually depend.

Men, of which we have an almost unlimited supply, can be organized, drilled and disciplined in a few months, and become better year by year, if the organization is kept up as it ought to be, and will cost little compared with iron clads and fortifications which, however important as assistants, are costly, and will take years and years before they can be put afloat or erected.

All energies, therefore, should be bent towards the preparation of our "living force," and it is to be hoped that Colonel Sanger's efforts in that direction will meet with success, and result in laws which will abolish the lawful provisions for flint-lock muskets,

spare flints and spontoons and give us efficient regiments of men armed with breech-loaders and plenty of metallic ammunition.

STEPHEN H. OLIN, *Assistant Adjutant General, First Brigade, N. G. N. Y.*—The system of *cadres* is particularly suitable to heavy artillery. In a squadron of cavalry or a horse battery, half taught men are worse than useless; but a large part of the service of a great gun can be performed by men ignorant of the mathematics of trajectories or the chemistry of high explosives.

Therefore the problem of sea-coast defense might be considered solved if every battery commander knew that the outbreak of hostilities would bring to his aid ten auxiliary batteries, which had been "linked" to his own and had annually received some weeks of instruction at his post and under his orders.

Colonel Sanger's paper sets forth the need of such a force and the possibility of obtaining it better than has ever been done before.

I should have doubted whether a short service system would benefit the regular artillery, and should have supposed that it would lose more in quality than it could gain in quantity from any reserve which would be established, but Colonel Sanger is certainly right in saying that the auxiliary force cannot be obtained by any practicable modification of our National Guard.

We used to have heavy artillery regiments in New York, but they soon became infantry in effect and afterwards in name as well. There are now projects for raising a heavy artillery corps here, but nobody supposes that it could find recruits enough to garrison the forts in our harbor.

The auxiliary artillery will not need costly armories, for its work will be done in the forts, but it will be necessary to pay the men adequately for their service with the colors and at a nominal rate while they remain in the reserve.

Just as our National Guard resembles the English Volunteers, so I should think that the English Militia system would furnish many suggestions for organizing the proposed force.

It is certain that we shall get no sea-coast defense without action by the National Government and the first step toward such action should be the appointment of such a commission as Colonel Sanger suggests.

Meanwhile, he has put us all under obligation by saying so well what so much needed to be said.

Brevet Brigadier General JOHN C. TIDBALL, *Colonel (retired)*

United States Army, Formerly Commanding the United States Artillery School.—The perusal of Colonel Sanger's paper gave me great pleasure and in a measure revived a train of thoughts so frequent with me when I was among you of the artillery as a living being.

I like every word of Colonel Sanger's article, and I find nothing in it out of harmony with my own views of the subject. The first part of it,—that relating exclusively to coast defenses,—is but the oft told story, harped upon for the last score of years by the ablest military talent of the country. But Colonel Sanger, in bringing it forward, modestly excuses himself on the ground that the story cannot be too often repeated, hoping thereby that it may meet the eye of some one yet sitting in darkness, and show him the danger of procrastination in a matter so vital to our nation. He has certainly treated this branch of his subject with clearness and force, using as a basis for his argument figures that do not lie and data that are beyond doubt.

He very justly lays the blame of our present state of defenselessness at the door of Congress. But suppose Congress should rise to the occasion and with wizzard wand call into existence fortifications and armament who are to defend these? who are to work the mighty engines of war and beat back the enemy's ships from our harbors?

And this brings us to the second part of his article, namely, the character and organization of artillery troops suitable for such responsible service.

He assumes, as every thinking person must, that we are not likely to have within a reasonable period a standing army equal to the requirements of war, and therefore must depend for the recruitment of armies upon hastily raised troops—in other words upon the militia, whether National Guard or other volunteers, under whatever name they may appear. He speaks in the most liberal and broad-minded manner of the burning necessity of having an increase to our present ridiculously small force of regular artillery; and this coming from a National Guardsmen lends manifold force to his utterances. He argues that as an increase is not likely soon to take place, except possibly in a very limited degree, it is manifestly wisdom to look to the National Guard system for some alleviation of the evil. He has evidently given much careful thought to this branch of his subject, and being familiar with the working of the National Guard system makes what I consider some very practical suggestions. These he presents in a formulated form on page 19 of the pam-

phlet. These suggestions he backs up with the most cogent arguments—brief but pointed. Agreeing so thoroughly with him leaves me nothing to say in the way of criticism; but upon my own hook I will venture to remark that the framers of the Constitution, in their excess of caution towards the military, left it somewhat defective by dividing the control of the militia force of the nation between the general government and the state governments. Resting thus between two stools it has never had a well defined foundation. No axiom of government is better founded than that every man of suitable condition owes military service to his country. This manifestly should be without any interference by individual states. All men not exempt, should be enrolled and organized into companies, regiments, brigades and divisions.

The general government should prescribe what proportion should be infantry, artillery, cavalry, and if desirable, engineers. This would enable the government to lay its hands upon the fighting force of the nation in the shortest space of time; and it would furthermore train the minds of men to the idea that they owe service to their country, and to some degree disabuse them of draft riot notions. Authority should be granted to the states, as at present, for maintaining volunteer organizations, to be used as now used, for suppressing riots and other purposes purely belonging to the states. But I am wandering—returning again to the point of the matter the government should hold out such inducements, as to cause National Guard organizations to take hold of artillery matters. Every possible facility should be afforded them for drill and instruction at our coast forts, and where the latter are inconveniently located or inadequate, temporary batteries armed with *modern* artillery should be provided. A law passed in the early eighties, (the origin of which I know something about) now grants such privileges, but to a very limited degree; nevertheless some states have done something under it towards artillery instruction. Heavy-artillery has none of that show-off about it that casts the glamor usually found so attractive. It is therefore necessary to hold out superior inducements in order to make it popular.

On page 31 the author discusses a system of payment which I think would be the proper line to follow. This should of course be done by the general government, since it is for general defensive purposes. States—as coast artillery is not required for the suppression of riots—cannot be expected to sustain such expenses, Congress should be induced to appropriate liberally and

continuously, for no good can come by going by fits and starts; artillery organization and instruction, to be effective must be continuous.

I think it should be the policy of every artillery officer to encourage in every possible way the organization of an auxiliary artillery, for it is in this line that he may expect advancement during war. It matters not how much instruction is given to the auxiliary force there will be a still higher degree that can only be found among those of the regular service who have devoted years to it, and a demand will then exist for their services which means promotion, volunteer or otherwise, to the ambitious.

The volunteer system has grown up with the nation and seems to just suit the genius of our people, and nothing can be more wise upon the part of regular officers than to work in harmony with it. A dislike to standing armies grew up in colonial times, and has continued ever since. We have passed through an aggregate of about sixteen years of war during the century of our existence and in all of our wars have had to rely upon volunteers for the bulk of our armies. The minds of our people are confirmed in the belief that this should always be so. It is therefore the duty of all to make the best of it.

That we must sooner or later have war, goes without saying. The history of mankind shows that each generation must have its war, a new set of people come to the front, impetuous as young bucks among savages, eager to put on their war paint and display their bravery. Civilized people are but savages galvanized and inwardly have the same feelings and are controlled by the same motives. Nothing is more illustrative of this fact than what has been passing the last month or so.

In all our schemes for the organization of the army we must bear in mind the kind of material we are liable to have in time of war.

We have before us the experiences of the civil war, and there are nowhere any signs that these experiences have become obsolete, troops will be called for in the same manner, and raised and mustered into the service in the same way. Companies of volunteers are raised through the personal influence of the captain (to be) and there are but few captains equal to raising a company of two or three hundred men such as is contemplated by the new tactical methods; and if they could raise such a company they could not take care of them in the field—at least at first, when their services would be most needed. Neither could inexperienced colonels manage such regiments as are

contemplated. Volunteer troops demand a greater percentage of officers than thoroughly disciplined and instructed troops. Our experience during the Rebellion was exhaustive on this point. After a long period of peace, generals of experience and of sufficient physical activity to stand the rough and tumble of field service become scarce, and a new set have to be picked up at random. These have to learn the art of handling men in large bodies and otherwise fulfilling the conditions of compaigning before heavy brigades, divisions and corps can be formed. This was another of the lessons learned during the Rebellion.

We are nearing the end of a generation since the close of our last war, and it cannot therefore be long before the next war comes. Then the gates to promotion will be thrown open and those who have struggled until they have become gray in the slough of despond will come forth with rank commensurate with their age and length of service.

HENRY W. CLOSSON, *Colonel 4th Artillery, U. S. Army.*—I have read Colonel Sanger's article on Sea-coast Defenses and Artillery Organization, and do not see that it leaves much more to be said or needs much commentary.

Enough has been written already and nothing done, at least little in comparison with what remains to be done and what has been stated as necessary year after year until one is sick of the subject. The responsibility rests with Congress. The amount of one single year's pension outlay would more than complete the entire sea-coast defenses, equip and arm them, and yet the annual expenditure on this most important element of national existence and honor is measured by a few thousand dollars, and the pension appropriation runs higher and higher into the second hundred million every year with hardly a word of objection—certainly none from the rumshops into which no small fraction of the money drifts—see police reports at and after every quarterly pay day.

A beginning has been made—the lines on which we are to advance are known—everything is done that can be done outside of Congress.

All that is wanted is the money, and if that is not given and if the same indifference and neglect continue through the future that have marked the past, some day we shall find ourselves at war, the sea-coast ravaged, and a thousand times the whole amount that would have prevented all this disgrace, will not by any means represent the damage and loss inflicted.

"Woe to the laggard that ever he was born
Who did not draw the sword before he blew the horn."

The organization of the artillery with short service and reserve with local territorial assignment for enlistment purposes, proposed by Colonel Sanger, is, I think, very desirable. These details would have to be worked into shape by the commission he suggests, the members of which should be designated by the Major General Commanding the Army.

This system is already at work in England with great gain in efficiency and economy over the old method.

But in this matter of sea-coast defense the Secretary of War, the General Commanding, the Engineer Department, the Ordnance Department and the various Fortification Boards have presented the national needs over and over again. There is no use in wasting time upon plans and reports, ignorance of which it would be absurd to assume, when all the information required has been repeated and piled away, until it overflows the shelves of every dealer in government publications.

When the artillery is placed in charge of the new armament with its complicated carriages and motive power, and all the machinery incident to disappearing systems, gun lifts, turrets, mines, etc., there will be demanded among the enlisted men a much larger proportion of mechanics and engineers than we are getting at present, or are likely to get with existing rates of pay. This will probably result in grading the men as 1st, 2nd and 3rd class according to capacity and employment.

In the National Guard as now constituted in the vicinity of our cities, there is a great abundance of the very material needed, and their instruction in the management of the new artillery will be correspondingly facilitated.

When the 12th New York came down to Fort Wadsworth some years ago for garrison service, the ease and readiness with which a detachment transported and mounted a heavy gun was remarkable, applying to it their own method of work and with very little superintendence outside of themselves.

JAMES CHESTER, *Captain 3rd Artillery, U. S. Army.*—So much has been written, officially and unofficially about the sea-coast defenses of the United States; and there has been such unanimity of opinion as to their present defects and requirements, that the continued indifference of the nation and its representatives to the dangers and necessities of the situation is almost

incomprehensible and certainly incompatible with belief in the truthfulness and honesty of the reports and recommendations officially made. Perhaps they have become so accustomed to the cry of "wolf" when there was no enemy in sight, that they have become callous to the cry from that quarter. Colonel Sanger's paper therefore, is welcome evidence that interest in the subject is widening and that correct ideas about it are percolating into the body politic. The nation may listen to the National Guard even if it turns a deaf ear to the army.

Colonel Sanger cites authorities in support of his contentions, mostly military men supposed to be experts on such subjects, and certainly makes out a strong case. But army men have always been unsuccessful advocates. Whether it be that the known hostility of our race to standing armies neutralizes their influence, or because they have no political pull, would be difficult to determine. But it is certain that their professional opinions have had but little weight with our legislators. General Sherman was considered crazy in 1861, because he declared that 200,000 men were needed in Kentucky; and General Grant was quietly ignored when he recommended the coast-wise canal, which would have simplified all the problems of coast defense, and at the same time made blockade impossible. But the army has said its say on coast defenses, and the question is now in the hands of those who alone can decide it.

But material defenses are only half the problem. Colonel Sanger emphasizes the fact that, in case of a foreign war the artillery forces of the nation would have to be suddenly expanded to twenty times, and probably thirty times their present numerical strength. The second question therefore is, how can such expansion be effective? Of course the men could be had in an emergency; but the efficient service of modern guns calls for trained artillerymen. We can never hope to have more than one regular artilleryman to every gun detachment when our coasts are fully manned, and that is hardly enough leaven for such a lump. It is perfectly clear that an army of men must be added to the sea-coast artillery the day war is declared against a foreign enemy; and it is equally clear that that army must consist of volunteers or militia. But untrained men behind a modern gun in actual war, would be as worthless as landsmen aloft in a gale of wind at sea. And it takes time to train an artilleryman. With average material it takes about three years to make a good, all round, efficient cannoneer, and at least five to make a gunner. The service of guns and mortars constitutes

only a small part of the artilleryman's duties. Mechanical maneuvers are at least equally important and much more difficult to learn. Guns will be disabled during a bombardment, and they must be replaced if the fight is to be continued. This is generally accomplished at night, and requires carefully trained artillerymen. One unskilled man in a maneuvering detachment at that kind of work, might do more damage in a moment than the enemy could do in a day. Men must be trained before they can be trusted at such work. Then the magazine and position finding staff cannot consist of green men. New men must be trained, sorted and assigned to duties for which they are fitted, before our batteries could be called efficient, and these operations require time. This the enemy is not likely to grant us. Manifestly the training must be done in advance, and the question is, how can it be accomplished? This may be called the third question.

Colonel Sanger discusses the second and third questions under six heads, which may be condensed into the following:

1. Increase of the sea-coast artillery (regular).
2. The creation of auxiliary artillery forces.
3. Uniform organization.
4. Reservists for regular batteries.
5. The localization of regular batteries.
6. The efficiency and sufficiency of artillery troops.

A full discussion of the questions involved under any one of these headings would require more space than "comments" are authorized to occupy. Colonel Sanger gives us many valuable hints, and makes, no doubt, some impractical propositions. But agitation is the way to enlightment. Those who have the power to determine, have also the right to hear all sides of the question. And so Colonel Sanger is entitled to thanks and I feel justified in offering the following as my solution of the problem.

1. A corps of artillery containing 100 heavy batteries.
2. The localization of batteries.
3. The organization of three militia batteries for every regular battery; the militia batteries to be linked to the regular one for instruction, training and service.
4. Uniform organization.
5. The linked batteries to join the regular battery annually for instruction, one at a time, and to have the benefit of the officers and non-commissioned officers of the regular battery as instructors.

6. On mobilization for war, the linked militia batteries to join the regular battery, thus constituting a battalion of artillery to be commanded by the captain of regulars with the volunteer rank of major.

Such an organization, and system of instruction and training, and service in war are simple and practical, and mobilization could be effected by an order of six words. "Militia batteries will join their stations."

And so, on the eve of war, the artillery could be promptly mobilized, and the militia batteries would join familiar stations, and meet familiar friends, and perform familiar duties at familiar guns under a familiar commander, all of which would not only be pleasant and desirable, but would add to their efficiency immensely.

Then the elasticity of the method is an important feature. There need be no limit to the number of linked militia batteries, but three would be most convenient, with such an organization, and if the war strength of a battery was 100 men, the regular artillery would be 10,000 strong, and the mobilized artillery 40,000.

C. L. Best, Jr., *1st Lieutenant 1st Artillery, U. S. Army.*—The artillery services of the country are certainly under obligations to Colonel Sanger for his strong and opportune presentation of much that relates to the artillery question. To us the subject is hardly new but in the mind of the country at large it seems to have little or no place.

As truly stated by the Secrerary of War: "The organization of the line of the army has undergone no material change since the close of the civil war." This for the artillery applies practically, for over seventy years. We drift along weak in numbers and burdened with an administrative and tactical form and traditions born when, in 1821, as an infantry with red facings we shed our battalion shell for regimental form.

We think of our cities and ports that have neither cannon nor defensive works worthy of the name; of artillery matters that in their numerous phases our organization does not fit; and, in this connection, of the fact that behind our puny force there stands hardly a trained sea-coast artillery soldier from among nearly seventy million people.

It is our sea-coast cities that the tidal wave of hostilities would strike on short notice after the rupture of peaceful relations. Speak of the possibility of a clash of arms and the country

points as evidence of our prowess to the giant strength developed in the civil war. Memory is dim to the fact, however, that though at first pitted against an enemy as unprepared as ourselves and lacking our resources, *over three months* elapsed before we could push less than 20,000 men into a battle from which the Union forces emerged without standing on the order of their going.

On the heels of a brief notice, England in 1882 bombarded the defenses of Alexandria and within about two months easily put 35,000 men, supplies and transport into Egypt and closed the campaign. The promptness with which the first aggressive blow is struck in these times is in keeping with the military systems and machines that exist in our age of steam and electricity.

The world has moved much in the past generation but American artillery affairs trail way back in the procession.

What the country needs generally in an artillery way is such a large question that no one legislative measure could cover it. So far, however, as concerns the immediate needs of the permanent artillery establishment the matter would seem to be one of no apparent difficulty if there be granted an increase of strength. The force is now so small that, varied artillery duties and number of harbors considered, it is impotent. Matters are unsatisfactory in several ways and will so continue until we become a body greater in numbers; energies specialized; a harmonious artillery whole.

First of all, the arm needs a head—a chief with immediate staff. Without a head, artillery affairs must continue chaotic whatever the strength.

It needs a promotion scale such that when attaining to the first grade of dignity and responsibility, *i. e.* to battery command, officers may not be from fifty years of age upwards as is now the case.

It needs a grouping of the mounted units under field officers who are responsible to and under direct supervision of the artillery head.

It needs the creation of sufficient siege artillery for instruction purposes.

It needs the placing of the chain of defenses in any one locality in the hands of the senior artillery officer there.

It needs inspectors for artillery, not in name alone but in fact.

It needs, for the sea-coast branch, such pay for its noncomissioned officers and such of its men as can qualify as firstclass gunners, as will secure and retain the intelligence

indispensable to this highest branch of the military art so far as concerns much of its enlisted part.

It needs better pay for the non-commissioned officers and qualified gunners of the mounted branches if, as should be the case, the regular field batteries are to be considered as schools for the supply of good material for officers of volunteer field artillery.

It needs, for the sea-coast branch at least, a reserve force that has passed through its ranks.

To it, unless the Engineers are much increased in numbers, should be turned over the torpedo subject. This very important matter the artillery now knows nothing about as it is, by law, in the hands of the Engineers whose abilities are not questioned. If ever threatened with foreign war we will need torpedoes in all harbors *immediately;* to expect this, together with other Engineer specialties, from the present little force of Engineer troops is leaning on a shadow.

Mark the transformation that would result from a reorganization based on sound artillery principles:

From the artillery fountain head would flow a continuous current of authority and supervision in technical matters, permeating all branches of the artillery forces wherever located. Under an uniform system rapid progress would be made in mastering the manipulations of the several kinds of sea-coast artillery machines now beginning to appear. With this would grow up (and keep pace with it) the indispensable range and position finding service now, after ten years, existing hardly more than in the imagination. No longer would we find sea-coast cannon standing for years untouched or without range tables. No longer would we find no head to a harbor's defenses, or, rather, as many independent heads as there are forts. The same daily attention given to other artillery affairs would be devoted to torpedo matters. The weekly inspection of sea-coast artillery troops instead of being, as now, as infantry at barracks, would be at the guns, magazines and engines for the gunnery men; at the range finders and converters for range finding specialists, and at the torpedo craft and appliances for the torpedoists. Perodic inspections by inspectors, instead, as now, of being practically confined to appearance at parade maneuvers and condition of small arms and accouterments, would look *primarily to artillery matters in all details.* Yearly the sea coast artillery reserve men would be at their posts for a short period and provision made for the accommodation and instruction of

such state artillery forces as would doubtless soon grow up. A scheme of mobilization complete as to minutest details would be in the hands of every sea coast artillery officer, state and national. The mounted branches would have to spare at any moment of emergency from its non-commissioned officers and qualified gunners, *competent* men for commissions in the volunteer field artillery.

The benefits that would result from an artillery organization have been but touched upon. On all matters, the commander-in-chief, through the chief of artillery on his staff, would have full understanding at all times.

So far, all in all and as far as it goes, the best idea of organization for our permanent artillery (an increase of present force assumed) yet laid before Congress is that appearing in Senate Bill 538, present session.

Our country, great in people and resources, seems to be getting kicking proclivities. One thing is certain. We must either furnish the necessary money to protect our harbors and provide the trained forces to make them effective, or, sooner or later, we must turn over the cash for some one else's defenses. Better, far, combine wisdom and weapons of war before it's too late.

PRESENT STATE OF THE STRUGGLE BETWEEN ARMOR AND ARTILLERY.

Translated from *Le Génie Civil*, November 16, 1895.

The struggle we have been witnessing since the Crimean war between armor for protecting ships and artillery for destroying them, might well be styled Homeric, were it not for the fact that it is carried on at the expense of the taxpayers of all nations. After passing through many stages, which we will present in a summary way, it has brought about entirely new conditions and revolutionized ship construction.

Armor first made its appearance on the floating batteries constructed to attack Kinburn.* Shortly after this Dupuy de Lôme laid down the first armored vessel, *La Gloire*, on which every part exposed to attack was protected by an iron sheathing, 110 millimeters (4⅓ inches) thick. Year after year the penetrating power of the projectile went on increasing, forcing the armor to increase in thickness at a corresponding rate. But in proportion as the thickness increased, the height of the armor diminished. The armor of the *Gloire* was 110 millimeter (4⅓ in.) thick, and 5.60 meters (18.37 feet) high; that of the *Colbert*, which marked the end of the first stage in the development of armor, was 220 millimeters (8⅔ inches) thick, and 2.70 meters (8.86 feet) high. Just then, about 1873, the problem assumed a new phase when the *Redoubtable* was laid down. Wood gave place to iron and steel in the construction, and the necessity of a protective deck to cover the propelling and evaporating machinery was recognized. It now looked as if the armor had fairly beaten the artillery, but the artillerists rapidly recovered their lost ground. They attacked armor 350 millimeters (13.78 inches) thick, by means of cannon of large caliber. The 0.42 meter (16.54 inch) cannon in France, and the 100-ton cannon in Italy necessitated still stronger armor; a thickness of armor of 450 millimeters (17.72 inches) was reached on the *Hoche*, and 550 millimeters (21.65 inches) on the *Formidable*. The artillery went on improving: by using slow burning powders it became possible to give to the projectile velocities till then unknown; 800 meters (2624.72 feet) a second has been attained by modern

* October 17, 1855.

French artillery; and by reason of these high velocities, it became possible to reduce the caliber without diminishing the destructive effects.

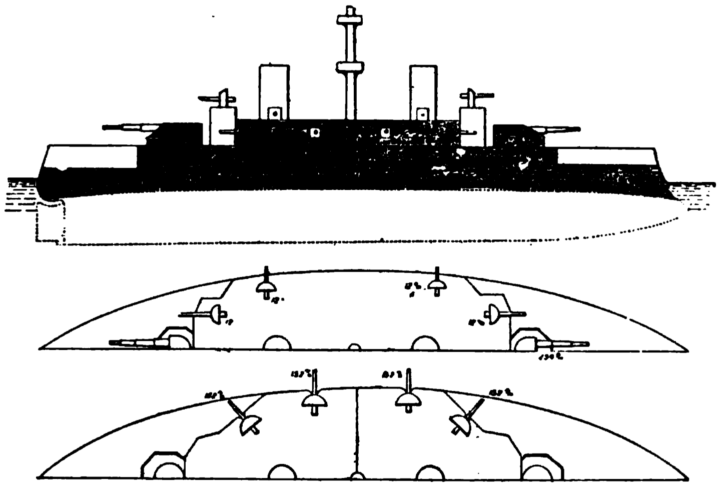


FIGURE 1.—The battle-ship *Amiral St. Bon* of the Italian Navy.
Length, 105 meters: width, 21.12 m.; displacement, 9800 tons; maximum horse power (French) 13,500; speed, 18 knots.

To this artillery, the metallurgists now opposed armor of greater and greater resistance. Instead of increasing the thickness, they had recourse to new materials. Iron had already for many years been replaced by steel plates, or compound armor, half iron and half steel; but now they began to employ nickel steel and chrome steel; and last of all, plates cemented by the Harvey process. The steel plate resisted a projectile that went through an iron plate of equal thickness; the special steels resisted projectiles with 25% more energy than that necessary to perforate iron of equal thickness; finally the Harveyized plates stopped projectiles that perforated steel plates of the same thickness. These steps in the metallurgy of armor have been made in less than six years, about the time required to build a battleship. The cost of armor still remains high; armor costing 110 francs ($21.00) for 100 kilograms (220 lbs.) ten years ago, costs to-day 270 francs ($51.00). By virtue of these improvements in metallurgy, it would still be an equal contest between armor and artillery, if other inventions favoring artillery had not intervened, and entirely changed the aspect of the question.

For a long time, it had been held by naval authorities, that to sink and destroy an armored vessel, it was necessary to perforate

the armor along the water line, in other words fire to sink the vessel. The real artillery ot combat was the great caliber armor-piercing artillery; shells or other exploding projectiles were used solely to destroy the crew or render the superstructure uninhabitable, no one thought of using shells to attack the vitals of the ship. With the advent of melinite, the construction of armored vessels experienced another change. In this, artillery gained so enormously on armor that it seemed doubtful if the ground lost would ever be regained. Giving up the idea of penetrating the ships it crushes it in by the powerful explosive effect of the new explosive. Protective decks for machinery and furnaces are but a slight defense if a melinite projectile penetrates into the interior of the ship and bursts there; this explosion demolishes everything within reach. The ship must seek another defense against this new danger which, in a way, takes it in reverse.

It was fortunately discovered that projectiles carrying high explosives could be broken up by a very thin plating, at least this holds true up to the present date. Hence to protect the ship against high explosives it was covered with thin steel (60 millimeters or 10 millimeters, 2.36 inch or .39 inch); this caused the shell to produce its disastrous effects outside the ship. As this steel covering meant additional weight, it was necessary to sacrifice some of the protection given to the hull along the water line. This was reduced in thickness from 420 millimeters to 250 millimeters (16.54 inches to 9.84 inches), and by way of consolation it was said that this thickness of 450 millimeters was in truth unnecessary. It had been calculated to resist projectiles at close range and striking normally, but these conditions will obtain but rarely in combat.

Thus the armor has been forced to yield to the artillery. Compelled to spread over the entire surface of the ship, it has become necessary to reduce its thickness and secure but a relative protection. However, even to-day it is still an adequate protection both against the armor piercing shot and the projectile with an explosive charge, yet it is certain that the ships now built are less protected against modern artillery than ships built ten years ago were against the artillery of that time. The attack has advanced faster than the defense; and it seems that the day is not far off when the artillerists will find means of penetrating armor with shells of large interior capacity; when this day comes, armor will no longer protect; its function will be but to limit the effects of the explosion.

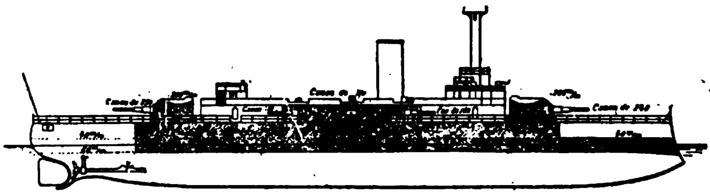


FIGURE 2.—The battle-ship *Monarch* of the Austro-Hungarian Navy.

Length, 93 meters; width, 17 m.; displacement 5500 tons; speed, 17.5 knots.

Perhaps the reader is tempted to conclude that in view of this superiority of the artillery, it might be just as well to give up all attempts at securing safety by means of armor, and seek to protect the ship by a cellular system of construction. This would be a serious error; armor, inadequate though it may be, is still an efficient defense against projectiles fired at long ranges or striking obliquely, and in all events, it will reduce the effects of dangerous hits. An unarmored ship will be destroyed by the first serious hit.

In this new aspect of the contest between armor and artillery, it becomes an interesting study to note the disposition of the armor in the warships that have been recently laid down. By making such a study we will see, that, as a consequence of what we have above referred to, there has taken place a veritable revolution in naval construction.

The Italians have hitherto steadily refused to build battleships of the type in vogue among other maritime powers; they have preferred fast cruisers of great speed with only the artillery protected by thick armor. But the ships they have recently begun present an entirely different character. The *Amiral St. Bon*, building at Venice, and the *Emmanuel Filibert*, building at Castellamare, of which we give a sketch (fig. 1) are protected by an armored belt of nickel steel, 250 millimeters (9.84 inches) thick, extending the entire length of the ship; above this belt there is a steel armor, 150 millimeters (5.91 inches) thick, protecting the central battery and the base of the great turrets. Besides this there are two protective decks, one 50 millimeters (1.97 inches) thick, placed over the battery, the other varying in thickness from 80 to 440 millimeters (3.15 to 17.32 inches), extending the whole length of the ship at the height of the upper edge of the armor belt.

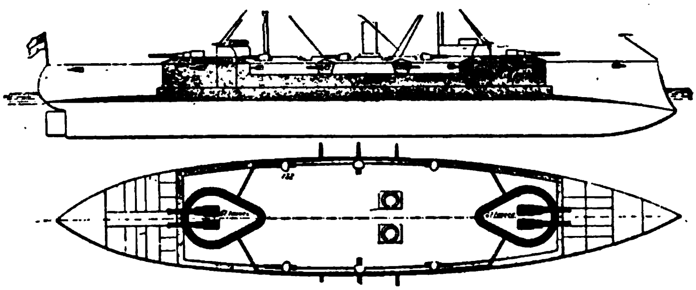


FIGURE 3.—The battle-ship *Royal Sovereign* of the British Navy.

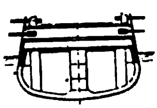


FIG. 4.—Transverse section of the *Royal Soverign.*

The Austrian navy, owing to its remarkably good organization, makes very judicious use of its comparitively limited means. In 1893, it laid down three small battleships, *Monarch*, *Wien*, and *Buda-Pest* (fig. 2), which have been designed like the latest Italian battleships with a view to protection against high explosives. The armored belt, shown in figure 2, is of nickel steel, 270 millimeters (10.63 inch) thick, and covers $\frac{5}{8}$ of the length of the ship, extending from the bow to an armored traverse of 200 millimeters (7.87 inches) thickness, placed in rear of the machinery; a protective deck of 40 millimeters (1.57 inches) thickness runs the entire length of the ship at the height of the upper edge of this belt. Above the armored floating caisson thus formed, an armor of 80 millimeters (3.15 inches) thickness protects the sleeping decks for $\frac{2}{3}$ of the length of the ship, as well as the upper battery deck for $\frac{1}{3}$ of the length. All the upper works are thus protected by 80 millimeters (3.15 inches). Behind the armored traverse, is a second protective deck, 60 millimeters (2.36 inches) thick, covering the steering gear. The artillery consists of four 24-centimeter (9.45 inch) cannon, placed by twos in closed turrets, six rapid fire cannon, 150 millimeters (5.91 inches), and sixteen small pieces.

Nothing brings out more pointedly the revolution that has taken place in naval construction than a comparison of the last two types of English battleships.

On the six ships of the *Royal Sovereign* type (figs. 3 and 4), which have been in service two years, and which were laid down a little before those now finishing in France, protection is obtained in the following manner: an armored belt 450 millimeters (17.72 inches) thick covers about $\frac{2}{3}$ of the length of the ship; two armored traverses separate this armored portion from the rest of the ship; two barbette turrets, with 400 millimeters (15.75 inches) of armor, are placed in front and in rear of this

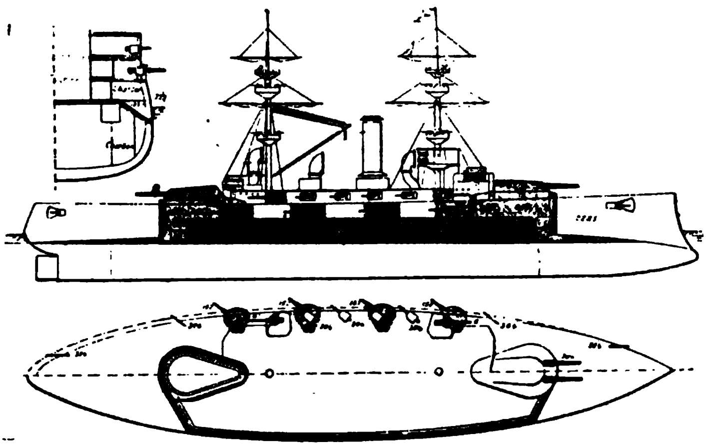


FIGURE 5.—The battle-ship *Majestic* of the British Navy.

armored caisson. Between these two turrets, the central part of the ship is protected by a thin sheet of armor of 126 millimeters (4.96 inches); the rapid fire cannon are located in armored casemates, in an unprotected battery. A 7-centimeter (2.76 inch) protective deck covers the central part of the ship at the height of the upper edge of the armored belt. The ends, front and rear, are secured against an inflow of water by means of simple compartments, under which is a turtle-back armored deck.

The ten battleships of the *Majestic* type (fig. 5), now building, differ totally from the preceding in the distribution of armor. This is clearly seen by comparing the two transverse sections. The central armor and the front and rear traverses have a thickness of but 228 millimeters (8.98 inches), instead of 450 millimeters (17.72 inches), but they cover the upper works for half their height instead of covering only to a height of 40 centimeters (15.75 inches) above the water line; the two main turrets front and rear have armor 250 millimeters (9.84 inch) thick; each of the smaller caliber pieces is located in an armored casemate in an unprotected battery. The armored deck slopes near the sides of the ship, forming a glacis 100 millimeters (3.94 inches) thick, rising from the lower part of the side armor to a level somewhat higher than the water line. The extremities of the ship are built as in the preceding type.

The transformation that has taken place in the protection given ships lies chiefly in a diminution of the thickness of the armor, with an increase of the surface protected, and in a new disposition of the protected decks. In fact, the new English battleships reproduce the disposition of the armor on the French

cruiser *Dupuy de Lôme.* To protect the battleship against modern weapons, it has been transformed into a powerful armored cruiser.

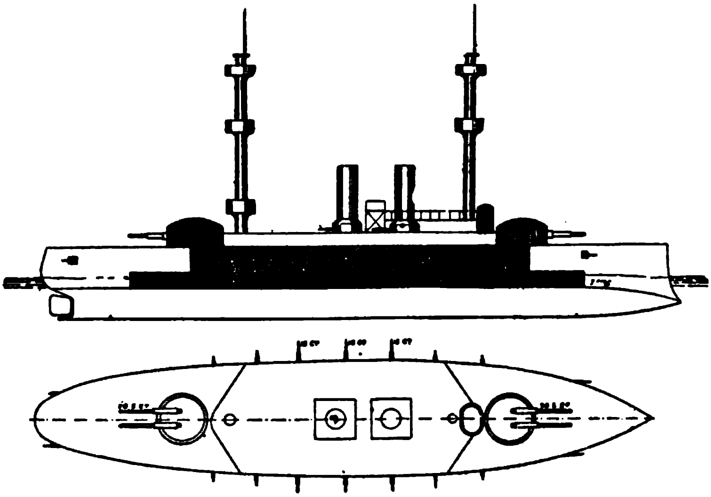


FIGURE 6.—The battle-ship *Cizoi-Veliky* of the Russian Navy.
Length, 103.6 m.; width, 20.24 m.; displacement, 8880 tons; maximum speed, 16 knots.

To complete this review of foreign battleships built to meet the demands of modern naval warfare, we will cite the Russian battleship *Cizoi-Veliky* (fig. 6) and the American ships of the *Oregon* type (fig. 7). We give sketches of these ships, which explain themselves. The protective deck of the *Cizoi-Veliky* has a maximum thickness of 7 centimeters (2.76 inches) arranged like that of the English battleships of the *Majestic* type.

Summing up, we see that all the naval powers are paying especial attention to the destructive effects of projectiles carrying high explosives. Some, like the Russians and the Americans, have simply superimposed on the old armored belt a thin armored citadel protecting the medium caliber artillery; others, like those we first cited, the English, Austrians, and Italians, have attacked the problem boldly and solved it without reference to tradition.

So far we have dealt only with foreign ships. It was France, however, that first pointed out the changes in naval construction that the employment of high explosives made necessary. The *Dupuy de Lôme* was laid down in 1888, and this, though but an armored cruiser with insufficient protection for a battleship, must still be regarded as the prototype of the most modern battleships, especially those of the *Majestic* type. But France after leading in the van of progress has fallen sadly behind, as she so often

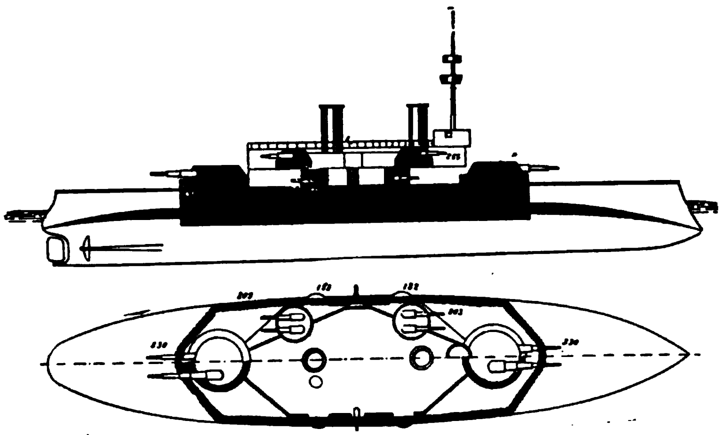


FIGURE 7.—The battle-ship *Oregon* of the United States Navy.
Total length, 105 m.; width, 22.50 m.; displacement, 10,288 tons; maximum speed, 17.5 knots.

does. Our battleships that are finishing, such as the *Charles-Martel*, or those recently laid down, such as the *Charlemagne*, offer large unarmored surfaces at vital parts which would readily admit high explosive shells into their interior. They are chiefly defended against armor piercing shot, whereas modern progress has made medium caliber rapid fire guns especially formidable. They seem built as if we had nothing to fear from the projectiles against which all other nations are arming themselves. Have we some secret that gives us an overwhelming superiority? And if we have such a secret to-day, will we alone possess it five years hence when our new ships are entering into commission? Such is the rapidity of modern progress, that prudence suggests that we should provide not only against arms now employed, but equally against those which it can be foreseen, will soon be in use.

Trans. by Lieutenant GEORGE BLAKELY, 2nd Artillery.

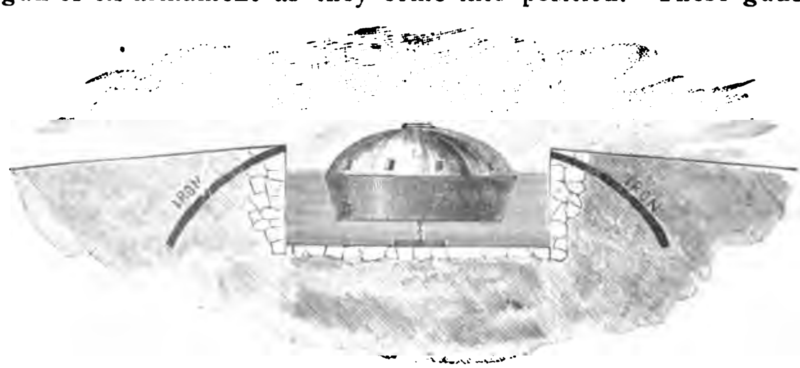
A PROPOSED SYSTEM OF HARBOR DEFENSE.

I desire to show how a harbor may, at a comparatively small outlay, be protected from capture by an enemy at sea. The circular floating battery designed to accomplish this purpose is 250 feet in diameter, and armed with 13-inch guns can deliver a shot every ten seconds from a steady platform, with guns and gunners perfectly protected. The system has been commended by high American authorities and has received the notice of the British Admiralty.

This defense, briefly described, consists of a circular, centrally anchored, revolving, *top-armored* vessel, floating in a small excavated basin, and surrounded by a protecting line of earthworks, within which the top-armored vessel is sheltered, and above the crest of which it delivers a rapid fire as it slowly revolves and brings its heavy guns successively into position.

The battery vessel enclosed by the wall can be lowered below the crest of its basin in such rare cases when this may be necessary by admitting water into compartments, and it can be made to rise quickly into fighting position above the parapet as the water is ejected.

This circular *armored* vessel revolves about its central anchorage in the small excavated basin once in from eight to ten minutes, or as fast as heavy guns can be loaded. It is easily moved by small propellers. As this vessel revolves, it discharges gun after gun of its armament as they come into position. These guns



have each a *perfect availability*—for the battery should be turned so as to bring each heavy piece to bear as soon as it can be loaded and handled. For example—if the top-armored vessel is

250 feet in diameter and is armed with fifty 13-inch guns, a 13-inch shot could be delivered every eight or ten seconds.

Since the battery ship is always in still water and has great stability, its fire should be more than commonly accurate, and as its gunners are safe they ought to be cool in action. This arrangement, having no complications, is not likely to get out of order. It is hard to see how such a battery can be disabled.

The top-armored vessel is strongly pivoted at its center and is thus able to revolve in a *very small basin*. It is difficult to hit, because of its comparatively small size, and it is concealed so far as possible by painting the shield a suitable color, and very little of its bulk appears above the surrounding parapet. In truth, only the *shield* is ever exposed, and the long curved and inclined surface of this can scarcely be given a direct blow. To a single ship of the enemy only one port hole can at one time be directly exposed.

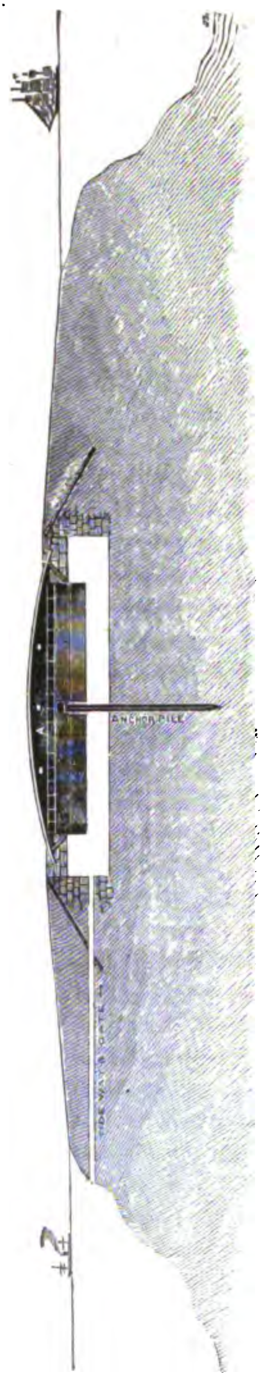
A circular vessel of this kind has great displacement (say 20,000 tons) and consequent stability. The heaviest armor is not required. The sides of the vessel are not exposed, and the curved shield armor cannot be penetrated. It is plain that the crew have nothing to fear from any form of ram or torpedo. Anchored in the middle of its basin, and consequently off shore on all sides, no assault need be apprehended. In the best position a battery of this character would occupy a small island or shoal. If from unforseen accident the circular vessel should sink, its shallow basin does not permit it to be submerged and the crew would be safe.

The curved lines in the larger cut marked *iron* are armor plates that prevent shells from entering and disturbing the masonry of the basin.

The space shown by the partitions immediately below A furnishes abundant air and ventilation, and is perfectly protected by the shield and earthworks.

B represents the inlet or sluice-way through which water enters the basin. A valve or gate prevents its escape, thus rendering the water level independent of the tides.

Such batteries would subject ships attempting a passage to a fire, far more concentrated and rapid than has yet been known. A few of these floating citadels placed inside of any harbor would render the enclosed waters unavailable anchorage for hostile ships, and a harbor protected by these defenses, having also a good torpedo plant, would seem to be safe from an enemy at sea.



These citadels are *inexpensive* when compared with any modren works of even limited efficiency.

In the contest between guns and armor, this system aims to give a decisive advantage to armor.

1st. By interposing earthworks.

2nd. By reducing the size and concealing the fortified target, thus making it difficult to hit.

3rd. By so greatly inclining and curving the surface of the armor shield that a penetrating blow shall be impossible.

A revolving battery of this character requires none of the heavy and complicated machinery necessary to maneuver disappearing guns or the turret of the monitor vessel. The guns themselves are manipulated by the simplest devices, since they have practically the stability of guns on shore (owing to the large displacement of the battery vessel and its floating always in still water), and they are put into action by the simple turning movement of the vessel. Unlike forts, and most ships, none of the guns of this battery are unavailable, all are equally useful, and may be brought to bear as *rapidly as they can be loaded.*

These defenses seem to form truly impregnable citadels. Shoals or reefs upon which they can be located are numerous in most harbors. The material dredged from the excavated basin will form an important part of the surrounding enbankment. Defenses of this character can be organized in a short time.

This system has advantages over the turret, on land or water. Its gently curved top outline rising gradually above the low sloping earthworks offers no marked target center, and is indeed hardly distinguish-

able at ranges within which approach to its heavy armament would be prudent. It has *no raising* or *revolving machinery* liable to break or be disordered in action, since it turns upon the water in its basin. If the water in this basin freezes, the ice can easily be broken up by the mere raising and lowering of the battery.

The vessel has ample room for its crew and the maneuver of its armament, and has such large displacement that it can be coaled, stored and provisioned for a siege, so that its garrison cannot be quickly starved out. It cannot be reached by the usual siege approaches nor mined.

Outside, and in rear of its earthworks, if placed in the best position, auxiliary vessels can find protection and issue out to attack the enemy as required. This battery vessel is also large enough to use every form of gun or shell yet known in warfare.

It is possible that the merits of the present systems for coast-defense are overestimated. It seems to many observers that they are chiefly distinguished for *slow* fire and complicated and expensive mechanical devices. Modern gun machinery has seldom received the fire of large up-to-date guns, or shells with high explosives. A disappearing plant for large guns has yet to be tested in actual warfare.

As before stated, this powerful revolving battery vessel aims not to be hit, or if hit, to escape without injury. It can certainly deliver a more rapid fire from heavy guns than has yet been known, and it possibly presents the simplest, *least expensive* and most impregnable defense yet suggested.

A battery vessel like that described, revolving in still water once in ten minutes, moves more slowly than ships in action, and can discharge more 13-inch shots in combat than could a fleet of twenty of the heaviest iron clads in the world.

The turret system was condemned for a long time. The objection that has most frequently been made to my battery vessel is that it might be frozen in its basin. Granting that it *might* be (which is doubtful, considering the distance from the protecting parapet to the water, and that the basin is so closely filled by the *warm* vessel) the lowering or raising of the ship (accomplished in a few minutes) would break it clear from the ice. Its own crew could also easily break up any ice forming, or even the rotation of its propellers would accomplish this.

The whole plan is so simple that I hardly know how to explain it further. It is the only way I know of for giving a rapid and concentrated fire from the largest guns. By simply rotating the battery vessel at the proper speed, every gun can be fired *as soon*

as loaded. No more rapid fire is *possible.* If a 13-inch gun can be loaded in ten minutes, then a vessel of 250 feet diameter would rotate once in ten minutes, a very slow speed, giving the guns a much slower movement than those in any iron clad vessel in action, and a slower rotation too than guns in any small revolving turret on land. This is clearly a great advantage, and with a steady platform for the guns, and crews pretty thoroughly protected, ought to ensure an accurate fire. No bearings or supports for turret or battery movement can be as simple as *water.* A very small power will give circular motion to the largest battery vessel. This plan is like a Colt's revolver (giving rapid fire to the largest guns) and like the revolver delivering a *concentrated fire.*

The space shown by the partitions immediately below A is for air and light, and is perfectly protected by the shield and earthworks.

B represents the pipe or sluice-way through which water enters the basin. The valve or gate prevents its escape. Thus, at all tides, a steady water level in the basin is assured. This cut represents a large rock in a harbor excavated for the basin. A *shoal* would be a more suitable place.

THOMAS L. STURTEVANT,
Quincy, Mass.

SEA-COAST ARTILLERY INSTRUCTION.

THE TRAINING OF PRACTICAL GUNNERS.

Colonel Maitland in his article on Gunnery in the *Encyclopædia Britannica*, recognizes the existence of two distinct branches of the subject, namely "The art of determining the motion of projectiles," and "The manipulation of artillery (cannon), so as to enable the projectile to produce the maximum effect." But strange to say he ignores the second branch of the subject in his article. Prince Hohenlohe, on the other hand, condenses all that he has written on the second branch of the subject—and he has been a very prolific writer—into the simple words "To hit."

Maitland and Hohenlohe are representative men. The first represents the technical, the second the fighting branch of the artillery. To the one gunnery is a science; to the other it is an art.

That the line of demarcation between the scientific and the practical gunner has been too lightly drawn, if not utterly ignored in our service, is sufficiently demonstrated by the teaching and training prescribed for the latter. The education and capacity of the class of men from which our practical gunners must be drawn, preclude the possibility of even approximate comprehension by such gunners, of many of the prescribed preliminaries to accurate gun laying. Ballistic formulas are merely *hocus pocus* to most of them, and as they are unnecessary to practical gun laying and would be impossible in war, they ought to be excluded from the practical gunner's course. Ballistic formulas are no more necessary to the practical gunner than they are to the snap shot. He has no time to analyze a deviation in action, and if he had, what would be gained by resolving it into its elements? He already has their algebraic sum before him, and that is the thing to be corrected. The deviation may be mostly due to the wind, or the powder, or some undetected injury to the muzzle sight. The practical gunner is indifferent as to the contributing causes. He has a fact before him, which contains, and is the resultant of, all known and unknown deviating causes, and his art tells him how to correct it. Why should he appeal to ballistics? Even if he were a scientific gunner as well as a practical one, he would have no time to do so in action. The correction must be made immediately; if it is not, his target may escape him. Why then

should he be taught to do otherwise? Observation and judgment should be his guides. Why then should he be taught to rely on the plotting board? And why should the observation and judgment of deviations be omitted in his training?

We may say then that practical gunnery as now taught to our enlisted men, is based upon problems in ballistics which very few of them have sufficient education to understand. The formulas are meaningless to most of them. If it were not that able and ingenious officers have computed tables and constructed charts for their benefit, the attempt to teach practical gunnery to enlisted men on the basis of ballistics would have been an unmistakable failure from the beginning. Whatever success has been attained is due to the officers referred to. Whistler's chart is the practical gunner's ready reckoner. Take it away and he is helpless. And, if his observation and judgment have been untrained, he would be helpless with it in battle. Neither time nor the turmoil of a bombardment would permit the calm consideration of even such a ready reckoner. If the gunner cannot correct observed deviations without appealing to chart or formula, he is untrained.

Let us look a little into his training then. Let us see what the character of a gunner's intellectual pabulum is supposed to be. We omit of course the drill book and the manual. These must be mastered before the man can be a gunner. Then, after he has reached that status, he is eligible for the "gunner's course." That course now lies before us. It consists of seven so-called circulars and is entitled "A Course of Instruction for Artillery Gunners." The first of this formidable series is known as Artillery Circular B. It is a treatise on "Gunpowder and High Explosives" and contains 46 pages. It might be described as a compendium of all that is known on the subject. But in perusing its paragraphs the conviction arises and becomes stronger and stronger as we proceed, that it is altogether beyond the capacity of the average enlisted man. To a man who knows no chemistry, such a treatise is little better than a book in an unknown tongue.

Circular C, the second of the series is a treatise on "Electricity and its Application in Artillery Practice," and contains 65 pages. Bearing in mind the class of men for which it was written, it will be unnecessary to characterize its contents after reading the following rule, which we take at random from page 15. "*The quantity of heat in calories produced in a given time in a conductor by a given current, is equal to the continued product of $\frac{24}{100}$, the square of the current in ampères, the resistance of the conductor in ohms, and the time*

in seconds." And this is assumed to be within the comprehension of men whose education never extended beyond the rule of three if it got that far. Of course Circular C contains much valuable and interesting information; but it is beyond the capacity of the majority of those for whom it was written.

But it is unnecessary to deal with the series in detail. Their titles sufficiently indicate the scope of the course. Circular D, is devoted to "The use of Meteorological Instruments," (50 pages); Circular E, "Range and Position Finding," (27 pages); Circular F, "Ballistics," (132 pages); Circular G, "Attack by Siege Operations," (40 pages); and Circular H, "Mathematics," (93 pages) with an appendix containing a complete table of logarithms.

We prize this collection very highly and believe that it would not be out of place in the curriculum of any first class college; but it is altogether beyond the capacity of the average enlisted man. But, be that as it may, the course is clearly scientific. A man might master it and remain utterly ignorant of practical gun laying. Indeed, gun laying, as an art, is nowhere alluded to in the circulars. Manifestly they were intended as an extra, to be studied by men who have already learned the art.

One of the first lessons would likely be the angle of departure. This can be explained readily enough, and gunners will soon learn to find it on the chart for any given range and muzzle velocity. But when jump is called in to determine the elevation the gunner gets suspicious. However as the muzzle velocity, the angle of departure and the range hang together so beautifully on the chart, the gunner gradually gets the idea that gunnery is an exact science, and that no reason exists why he should not be able to hit anything visible within range. The reaction that follows target practice may be imagined.

But we must not linger too long over these lessons. Computing the range, or rather extracting it from the chart, the angle of departure and the muzzle velocity being the known quantities, becomes an interesting and easy exercise, even to men with a very limited knowledge of arithmetic. The gunner is fascinated with it in proportion to his ignorance of the laws upon which it is constructed. His faith in it is sublime until he comes to test its accuracy on the practice ground. Then the instructor has to explain the difference between theoretical and practical results as best he may.

There are several other operations in the schedule of prelimaries to accurate gun laying, but we pass them by. We have

said enough to show what accurate gun-laying demands under our present system, and indicated one of the reasons—we think the principal one—why we have so few really practical gunners.

Having finished with the theoretical we now turn to the practical training of gunners. This need not detain us long as we shall pass over drill and mechanical maneuvers, and confine our remarks chiefly to artillery target practice and the prescribed preliminaries thereto.

That the guns in any sea-coast position may be always ready for service certain requirements have been prescribed in orders. Traverse circles are to be graduated in azimuths; a chart of the harbor on the scale of 100 yards to the inch and divided into squares 100 yards to the side is to be prepared: a base line is to be measured and plotted on the chart and its azimuth determined: tables of azimuth, elevation and range are to be calculated: gunners are to be practiced at judging distances, reading sights, estimating velocity of wind, aiming guns at stationary and moving targets, and plotting the positions of targets and the fall of shots.

The artillery target practice prescribed in orders as a test of the gunner's practical qualifications would be classed by any unprejudiced observer as scientific. The array of apparatus is in itself imposing.

If we are right in our assumptions that the gunner's art is a trade to be learned, and that it consists in correcting observed deviations, most of the troublesome problems which now distract and confuse the practical gunner might be eliminated from his course. His attention could then be concentrated on a single fact, which he knows to be the algebraic sum of many misty elements. To him the fact is everything, the misty elements nothing. Lateral and longitudinal deviations are what he has to deal with. He must learn to recognize them with the naked eye within certain distances and to correct them with the promptness and skill of a master of the art. His whole training should have that object in view.

Of course a master gunner must be familiar with his gun. He must know it, not so much perhaps for what it is, as for what it can do. It is a general but erroneous belief that if a gunner can make good practice with one gun he can do so with another. No doubt the ballistic problems are similar; but as already said no two guns shoot alike.

As already said a gunner trained on the basis of ballistics, unconsciously acquires the idea that he can hit anything visible

within range. When he is confronted with a deviation then, his first impulse is to correct it in accordance with the formulas. He gives no consideration to the gun. Now the deviation may be within the normal error of the gun at that range, and any change in the laying may result in a greater error in the opposite direction. This will certainly be the case if the first shot happens to be a minimum and the second a maximum. It is important, therefore, that the gunner should not only know, but constantly bear in mind the normal deviation of his gun.

The normal deviation of a gun is the rectangle which contains all the shots fired at a given range with identical loading, laying and atmospheric data, and all attainable accuracy in aiming. This rectangle should be the bull's eye of the practice target. Shots striking within it should be scored a hit, no matter how near the outer limits of the rectangle they may strike. And so no correction in the laying for the next shot would be called for. The dimensions of the rectangle of deviations of the gun then, ought to be an important element in gun-laying.

For classes of guns, the normal rectangle of deviation can generally be deduced from the record of firing of the proof gun by the Ordnance Department. But practical gunners know that individual guns have their own rectangles. Commanding officers therefore should cause to be determined with all possible accuracy, the normal deviation of every gun under their command at the range of, say, one mile, for the information and guidance of gunners; and the dimensions of the rectangle thus determined should be entered on the artillery descriptive book.

The normal rectangle of deviation of his gun should be constantly kept in mind by the gunner at practice or in action. There is no surer way to waste ammunition than continual adjustment of the cannon sight for errors within the normal deviation of the gun. Any one who has witnessed artillery target practice cannot have failed to notice the frequency of this great mistake. A shot falls short, say close to the inner limit of the rectangle, which may be a goodly number of yards, and the gunner forthwith corrects for the shortage, and is disgusted to find that his next shot falls much further over than the previous one did short. If the rectangle was the bull's eye he would never make such a mistake.

The normal rectangle of deviation having once been determined, half its dimensions should be taken as the unit of estimation. The greatest distance at which that unit can be recognized

would be the limit of distinct vision. Beyond that limit good practice cannot be had, unless the gunner is assisted by a position-finding staff, or an observer in some side position. as nearly as may be at at right angles to the line of fire. From such a position a trained gunner can easily estimate the longitudinal deviation of a shot in terms of the normal deviation of the gun up to extreme range.

Practice beyond the limit of distinct vision would always be deliberate, and the assistance of a position finding staff would perhaps be practicable. It is only at ranges inside that limit, when, in action, the guns would be worked well up to their capacity, that position finding, so far as the point of fall of individual shots is concerned, becomes impracticable. And so, at the very crisis of the battle, the untrained gunner deserted by his position-finding assistants, would find himself helpless. The bombardment of Alexandria taught naval commanders a lesson which they are not likely to forget, and the lesson is "long range fighting is unprofitable." If therefore it becomes necessary for a fleet to attack shore batteries, it is reasonable to suppose that they will fight at a range from which all their guns —even their machine guns—will be effective. Now such a proceeding on the part of an enemy would compel our gunners to fight under conditions not contemplated in their training. It would render our position finding staff and apparatus worthless, and eliminate most of our scientific accessories from the action. It would deprive our gunners of the help to which they had always been accustomed, and throw them on their own untrained resources at a moment when perfect work was required. Hence the importance of training in artillery marksmanship at short ranges without the assistance of a position finding staff.

The operation of "bracketing a target," which should be the test of a gunner's skill in field artillery, is unnecessary in sea coast service. In the former the unevenness of the ground makes the estimation of longitudinal deviations impracticable. Consequently no such estimation is attempted. Observers report "over" or "short" only, without specifying distance. With sea-coast batteries the case is different. There are no obstructions to view on their field of fire, and deviations can be estimated in terms of the normal, to considerable distances, depending on the height of the observer above the water. The sea-coast gunner creeps up to his target. He prefers to have his first shot short. The observer if he is other than the gunner himself, reports "short, over one," or "short, under one," or "over," according as the

longitudinal deviation was over or under the normal, or went clear over the target. In action this estimation is made by the battery commander; in practice it is made by the gunner. Lateral deviation is easily estimated. In action the lieutenant with the gun attends to it; in practice the gunner.

Officers and gunners of sea-coast batteries then, should be trained observers. Of course the best way to train them would be by actual firing; but expense makes that method impracticable. Some more economical method must be devised. Perhaps the following would be useful.

With a buoy in tow an officer in charge of a boat could lengthen or shorten the tow line at pleasure, and by raising and lowering a signal flag invite estimation by the officers and gunners at the battery, keeping a record of the length of tow line each time. Comparison between the actual length, and the several estimations of it, would soon disclose the most capable observers in the battery, and what is equally important to know, the most incapable.

With the assistance of the position-finding staff practice in the estimation of deviations could be had in firing guns of any kind or caliber. Obsolete guns and projectiles, and even damaged powder, might be used for this purpose with quite as valuable results as high power guns.

For laying guns at long ranges, that is, beyond the limit of distinct vision, two methods are practiced, namely "direct aiming," and "aiming by azimuth." Both methods require the assistance of a position-finding staff. The first method needs no description. It may be called the old fashioned way. The gunner gets the distance of the target from the position-finding staff; takes the corresponding angle of departure from his ready reckoner or range table; corrects for jump, wind, weight of shot, and height of gun above the water; and then sets his deflection scale so as to counteract the drift and lateral component of the wind; and aims the gun as he would a rifle. Quite a complicated operation. But the most unsatisfactory part of aiming a gun in this way is the traversing. The cannoneers have no guide but the gunner's signals or commands, and as it requires the combined strength of two or more men to move the gun, they are sure to traverse it beyond the desired point, several times perhaps, before the gunner is satisfied. During the excitement of actual battle, this difficulty would doubtless be increased.

Aiming by azimuths is easier, speedier and more accurate,

provided always that the azimuths and azimuth tables are accurate. Passing a true meridian through the gun-pintles of ten or a dozen guns situated in different parts of the work, or it may be on different sides of the channel, is not an easy undertaking. The most important part of the operation from the gunner's point of view, is to get the axes of all the guns parallel. This can be accomplished by aiming them all simultaneously at the same star. Then, as the azimuth of the base line is known, measure the angle contained by the line of sight of any of the guns and the base line. The azimuth of the guns as then pointed will be the azimuth of the base line, plus or minus the angle contained by it and the line of sight. The points indicated by the index fingers on the traverse circles of all the guns should be carefully marked as initial points for the graduation of the circles.

The accurate graduation of the traverse circles is also a difficult operation, especially when the guns are mounted. The writer has had very good results by the following method:

Find the exact radius of the traverse circle measured to the outer edge of the traverse plate. This should be done by actual measurement and for every traverse circle. From the initial points already marked on all the traverse circles, lay down the radius as a chord. Thus we have arcs of 60°. Bisect for arcs of 30°. Bisect again for 15°. Divide the 15° arc by trial with a pair of dividers into three equal parts for 5° arcs. Then have a pattern made of some hard, close grained wood, so that it will fit exactly on the outside of the traverse plate, and cover at least one 5° arc. Transfer a 5° arc to the pattern; divide it by trial into degrees; by bisection into half degrees; and by trial into 10′ arcs, which will be as small as it is necessary to go. Then transfer the graduations from the pattern to each of the 5° arcs on the traverse circles, and number them in true azimuths and the operation is completed.

It is important that all the methods employed should be within the comprehension of the average gunner. Indeed gunners should do all the work. For this reason the azimuth table should be constructed graphically. Only the squares covering navigable waters should be considered. To determine the centers of selected squares two diagonals should be lightly drawn in each with a pencil. Then centering one of the long armed protractors on the position of the gun and making the zero line coincide with the meridian passing through that point, fasten the protractor securely in that position. Then, having prepared a table

with columns for the designation of the squares, the azimuth, elevation, and distance of their centers, begin at extreme range with, say the left column of squares; bring the fiducial edge of the long arm of the protractor to the center of each square in that column, reading the azimuth of each and recording it in the column of the table headed "azimuths," opposite the proper designation. These readings are the true azimuths of the square centers. The other columns of squares are dealt with in the same way.

For ranges, remove the protractor and mount the range scale on the gun position; measure the exact distance to the center of each square, in the same order as that followed for azimuths; and record the distance in yards, opposite the proper designation, in the column headed "ranges."

For elevations take from any good range table or Whistler's chart, the proper elevations for the distances recorded, and enter them in their proper places in the column headed "elevations," and the table is complete. If Whistler's chart is used jump must be subtracted from the angle of departure for the elevation.

In aiming by azimuth two difficulties are encountered which greatly disturb the accuracy of the method, both of which might be avoided by a very simple addition to the outfit. First, the aiming is always at the center of a square and the object intended to be hit is not necessarily in that position; and second, the target may be in motion and its probable position when the shot arrives must be prognosticated. There are so many chances of error, especially in the second of these contingencies that some better method is an absolute necessity if the azimuth aiming of guns is to be practically useful. There is a third defect in the method which also calls loudly for a remedy. The azimuth of the target reaches the gunner through too many intermediaries to be either prompt or reliable, and the ingenious device of Lieutenant Rafferty, and other contrivances of a like character, aggravate the evil. To be of practical utility the azimuth of the target must reach the gunner instantly and accurately. To accomplish this we would suggest the following:

Giving the azimuth should be the last operation in laying the gun. Then, if every battery were provided with an azimuth telescope, mounted on a vertical axis and having an index finger which sweeps an azimuth arc graduated exactly as are the traverse circles, the captain of the battery would be able to follow the target and have the azimuth of his guns corrected to the very moment of firing. He could also, if he was an expert, eliminate

the error due to time of flight. Such an instrument at every battery would double the efficiency of the guns and greatly simplify the operation of aiming.

Mortars, which are destined to play an important part in sea-coast defence, should always be aimed by azimuth. The azimuth telescope therefore, would be an essential part of the outfit of a mortar battery. With a position-finding staff furnishing the distance of the target every minute, and the battery commander furnishing the true azimuth of the target every instant during the aiming, up to the moment of pulling the lanyards, the aiming of mortars might be made, not only exact but expeditious. Moreover the skill and judgment of the captain could compensate for drift, wind, and time of flight without calculation or consultation; the azimuths being mentally corrected before being announced to the gunner. By such a method mortar laying might be made, not only easy, but as already said exact and expeditious.

But we have said enough to show our dissatisfaction with the present method of teaching and training practical gunners, and to indicate the method which we prefer. We cannot make scientific gunners out of the available material, and we cannot make practical gunners by cramming average enlisted men with scientific methods which few if any of them are able to understand.

Captain JAMES CHESTER,
3d Artillery.

RANGE TABLE FOR THE 10-INCH B. L. RIFLE, STEEL.

Weight of projectile 575 lbs. M.V. = 1950 f.s. $c = 0.9.\ \frac{\delta_{\prime}}{\delta} = 1.$

Wind, none.

Range in yards.	Angle of departure. (φ)	d	$\Delta'(\varphi)$	$\Delta''(\varphi)$	Time of flight. T	Drift. (Yds.)	Angle of fall. (ω)	Striking velocity. (v_ω)	Slope of descent at point of fall. (S_ω)	Penetration in steel. (τ)
100	0° 04'.4	4.4	0'.0	0'.2	0''.16	0.0	0° 04'	1937	859.4	19''.8
200	0 08 .8	4.4	0 .0	0 .4	0 .31	0.0	0 09	1924	382.0	
300	0 13 .2	4.5	0 .0	0 .6	0 .47	0 0	0 14	1911	245.6	
400	0 17 .7	4.5	0 .0	0 .8	0 .63	0.1	0 18	1899	191.0	
500	0 22 .2	4.6	0 .1	1 .0	0 .79	0.1	0 23	1886	152.8	
600	0 26 .8	4.6	0 .1	1 .2	0 .95	0.1	0 27	1873	127.3	
700	0 31 .4	4.7	0 .1	1 .4	1 .11	0.1	0 32	1861	109.1	
800	0 36 .1	4.7	0 .1	1 .7	1 .27	0.2	0 37	1849	94.2	18.5
900	0 40 .8	4.7	0 .1	1 .9	1 .43	0.2	0 42	1837	82.8	
1000	0 45 .5	4.8	0 .2	2 .2	1 .59	0.3	0 47	1824	73.2	
1100	0 50 .3	4.9	0 .2	2 .4	1 .76	0.3	0 53	1812	65.5	
1200	0 55 .2	4.9	0 .3	2 .7	1 .92	0.4	0 58	1800	59.3	
1300	1 00 .1	4.9	0 .3	2 .9	2 .09	0.4	1 04	1788	54.1	
1400	1 05 .0	5.0	0 .4	3 .2	2 .26	0.5	1 09	1776	49.8	
1500	1 10 .0	5.0	0 .5	3 .4	2 .43	0.6	1 15	1764	45.8	
1600	1 15 .0	5.1	0 .6	3 .7	2 .60	0.7	1 21	1752	42.4	17.2
1700	1 20 .1	5.1	0 .6	3 .9	2 .77	0.8	1 27	1741	39.5	
1800	1 25 .2	5.2	0 .7	4 .2	2 .94	0.9	1 33	1729	37.3	
1900	1 30 .4	5.2	0 .8	4 .4	3 .12	1.0	1 39	1718	34.7	
2000	1 35 .6	5.2	0 .9	4 .7	3 .29	1.1	1 45	1707	32.7	
2100	1 40 .8	5.3	1 .0	4 .9	3 .47	1.2	1 51	1696	31.0	
2200	1 46 .1	5.3	1 .1	5 .2	3 .64	1.4	1 57	1684	29.3	
2300	1 51 .4	5.4	1 .2	5 .4	3 .82	1.5	2 04	1673	27.7	
2400	1 56 .8	5.4	1 .3	5 .7	4 .00	1.7	2 10	1662	26.4	15.9
2500	2 02 .2	5.5	1 .4	5 .9	4 .18	1.8	2 17	1651	25.1	
2600	2 07 .7	5.6	1 .6	6 .2	4 .36	2.0	2 23	1640	24.0	
2700	2 13 .3	5.6	1 .7	6 .5	4 .55	2.2	2 30	1629	22.9	
2800	2 18 .9	5.7	1 .8	6 .8	4 .73	2.4	2 37	1618	21.8	
2900	2 24 .6	5.8	1 .9	7 .1	4 .92	2.6	2 44	1607	20.9	
3000	2 30 .4	5.8	2 .1	7 .5	5 .11	2.8	2 52	1597	20.1	
3100	2 36 .2	5.9	2 .2	7 .8	5 .30	3.0	2 59	1587	19 2	
3200	2 42 .1	5.9	2 .4	8 .2	5 .49	3.2	3 07	1577	18.4	14.8
3300	2 48 .0	5.9	2 .6	8 .5	5 .68	3.4	3 14	1567	17.7	

Range Table (continued).

Range.	φ	d	$\Delta'(\varphi)$	$\Delta''(\varphi)$	T	Drift.	ω	v_ω	S_ω	τ
3400	2° 53′.9	6.0	2′.8	8′.9	5″.88	3.7	3° 22′	1557	17.0	
3500	2 59 .9	6.1	3 .0	9 .2	6 .07	3.9	3 30	1547	16.3	
3600	3 06 .0	6.1	3 .2	9 .6	6 .27	4.2	3 38	1537	15.7	
3700	3 12 .1	6.2	3 .4	9 .9	6 .46	4.4	3 46	1527	15.2	
3800	3 18 .3	6.2	3 .6	10 .2	6 .66	4.7	3 54	1517	14.7	
3900	3 24 .5	6.3	3 .9	10 .5	6 .86	5.0	4 02	1507	14.2	
4000	3 30 .8	6.3	4 .1	10 .8	7 .06	5.3	4 11	1497	13.7	13.7
4100	3 37 .1	6.3	4 .3	11 .0	7 .26	5.6	4 20	1487	13.2	
4200	3 43 .4	6.4	4 .6	11 .3	7 .46	5.9	4 29	1478	12.8	
4300	3 49 .8	6.5	4 .8	11 .6	7 .66	6.2	4 38	1468	12.4	
4400	3 56 .3	6.5	5 .1	11 .9	7 .87	6.6	4 47	1459	12.0	
4500	4 02 .8	6.6	5 .4	12 .2	8 .08	6.9	4 56	1449	11.6	
4600	4 09 .4	6.6	5 .6	12 .5	8 .29	7.3	5 06	1440	11.2	
4700	4 16 .0	6.7	5 .9	12 .8	8 .50	7.7	5 15	1430	10.8	
4800	4 22 .7	6.8	6 .2	13 .1	8 .71	8.1	5 25	1421	10.5	12.7
4900	4 29 .5	6.8	6 .5	13 .4	8 .92	8.5	5 35	1412	10.2	
5000	4 36 .3	6.9	6 .8	13 .8	9 .14	8.9	5 45	1403	9.9	
5100	4 43 .2	6.9	7 .1	14 .1	9 .36	9.3	5 55	1394	9.6	
5200	4 50 .1	7.0	7 .4	14 .5	9 .58	9.8	6 05	1385	9.4	
5300	4 57 .1	7.2	7 .7	14 .8	9 .80	10.2	6 15	1376	9.1	
5400	5 04 .3	7.4	8 .0	15 .2	10 .02	10.7	6 26	1368	8.9	
5500	5 11 .7	7.5	8 .3	15 .6	10 .24	11.2	6 36	1359	8.6	
5600	5 19 .2	7.5	8 .7	16 .0	10 .47	11.7	6 47	1351	8.4	11.8
5700	5 26 .7	7.6	9 .0	16 .4	10 .69	12.2	6 58	1342	8.2	
5800	5 34 .3	7.5	9 .4	16 .8	10 .92	12.8	7 09	1334	8.0	
5900	5 41 .8	7.6	9 .8	17 .2	11 .15	13.4	7 20	1326	7.8	
6000	5 49 .4	7.6	10 .2	17 .6	11 .38	14.0	7 32	1318	7.6	
6100	5 57 .0	7.6	10 .6	18 .0	11 .61	14.6	7 44	1310	7.4	
6200	6 04 .6	7.6	11 .1	18 .4	11 .85	15.2	7 56	1302	7.2	
6300	6 12 .2	7.6	11 .5	18 .8	12 .08	15.8	8 08	1294	7.0	
6400	6 19 .8	7.8	12 .0	19 .2	12 .32	16.5	8 20	1286	6.8	11.0
6500	6 27 .6	7.9	12 .5	19 .5	12 .56	17.2	8 32	1278	6.6	
6600	6 35 .5	8.0	13 .0	19 .9	12 .80	17.9	8 45	1271	6.5	
6700	6 43 .5	8.2	13 .5	20 .2	13 .04	18.6	8 58	1264	6.3	
6800	6 51 .7	8.3	14 .0	20 .6	13 .28	19.3	9 11	1257	6.2	
6900	7 00 .0	8.3	14 .5	21 .0	13 .52	20.0	9 24	1250	6.0	
7000	7 08 .3	8.4	15 .1	21 .5	13 .77	20.8	9 38	1243	5.9	
7100	7 16 .7	8.5	15 .6	21 .9	14 .02	21.5	9 51	1236	5.7	
7200	7 25 .2	8.7	16 .2	22 .4	14 .27	22.3	10 05	1229	5.6	10.3
7300	7 33 .9	8.8	16 .8	22 .9	14 .52	23.1	10 19	1222	5.4	
7400	7 42 .7	8.8	17 .4	23 .4	14 .77	24.0	10 33	1216	5.3	
7500	7 51 .5	8.9	18 .0	23 .9	15 .02	24.8	10 47	1210	5.2	
7600	8 00 .4	9.1	18 .6	24 .5	15 .28	25.7	11 02	1204	5.1	
7700	8 09 .5	9.2	19 .2	25 .0	15 .53	26.6	11 17	1198	5.0	
7800	8 18 .7	9.3	19 .9	25 .6	15 .79	27.6	11 32	1192	4.9	

Range Table (continued).

Range.	φ	d	$\Delta'(\varphi)$	$\Delta''(\varphi)$	T	Drift.	ω	v_ω	S_ω	(τ)
7900	8° 28′.0	9.3	20′.5	26′.1	16″.05	28.6	11° 47′	1186	4.8	
8000	8 37.3	9.4	21.2	26.7	16.31	29.6	12 02	1180	4.7	9.7
8100	8 46.7	9.4	21.8	27.1	16.57	30.6	12 17	1174	4.6	
8200	8 56.1	9.4	22.5	27.6	16.84	31.7	12 33	1168	4.5	
8300	9 05.5	9.5	23.2	28.1	17.11	32.8	12 48	1162	4.4	
8400	9 15.0	9.5	23.9	28.6	17.38	33.9	13 04	1157	4.3	
8500	9 24.5	9.6	24.6	29.0	17.65	35.0	13 20	1152	4.2	
8600	9 34.1	9.6	25.3	29.4	17.92	36.2	13 37	1147	4.1	
8700	9 43.7	9.7	26.0	29.8	18.19	37.4	13 53	1142	4.0	
8800	9 53.4	9.7	26.7	30.2	18.47	38.6	14 10	1137	4.0	9.2
8900	10 03.1	9.8	27.4	30.6	18.74	39.8	14 27	1132	3.9	
9000	10 12.9	9.9	28.2	31.0	19.02	41.1	14 44	1128	3.8	
9100	10 22.8	10.1	28.9	31.4	19.30	42.4	15 01	1123	3.7	
9200	10 32.9	10.2	29.7	31.9	19.58	43.7	15 18	1119	3.7	
9300	10 43.1	10.3	30.5	32.4	19.86	45.0	15 35	1115	3.6	
9400	10 53.4	10.4	31.3	33.0	20.14	46.4	15 52	1111	3.5	
9500	11 03.8	10.5	32.1	33.5	20.42	47.8	16 09	1107	3.4	
9600	11 14.3	10.6	33.0	34.1	20.71	49.2	16 27	1103	3.4	8.9
9700	11 24.9	10.6	33.8	34.6	21.00	50.7	16 44	1100	3.3	
9800	11 35.5	10.7	34.7	35.2	21.29	52.2	17 02	1097	3.3	
9900	11 46.2	10.8	35.5	35.8	21.58	53.7	17 20	1094	3.2	
10000	11 57.0	10.9	36.4	36.4	21.87	55.2	17 38	1991	3.2	
10100	12 07.9	11.0	37.2	37.1	22.17	56.8	17 56	1088	3.1	
10200	12 18.9	11.2	38.1	37.9	22.47	58.5	18 14	1085	3.0	
10300	12 30.1	11.3	39.0	38.7	22.77	60.1	18 32	1082	2.9	
10400	12 41.4	11.4	39.9	39.5	23.07	61.8	18 51	1080	2.9	8.6
10500	12 52.8	11.5	40.8	40.4	23.37	63.6	19 09	1077	2.8	
10600	13 04.3	11.7	41.7	41.2	23.68	65.5	19 28	1075	2.8	
10700	13 16.0	11.7	42.6	42.1	23.98	67.3	19 47	1073	2.7	
10800	13 27.7	11.8	43.5	42.9	24.29	69.2	20 06	1071	2.7	
10900	13 39.5	11.9	44.4	43.5	24.59	71.2	20 25	1069	2.7	
11000	13 51.4	11.9	45.4	44.1	24.90	73.2	20 44	1067	2.7	
11100	14 03.3	11.9	46.3	44.7	25.21	75.2	21 03	1065	2.7	
11200	14 15.2	12.0	47.3	45.2	25.52	77.3	21 23	1063	2.6	8.4
11300	14 27.2	12.0	48.2	45.8	25.83	79.4	21 42	1061	2.6	
11400	14 39.2	12.0	49.2	46.4	26.14	81.6	22 02	1060	2.5	
11500	14 51.2	12.1	50.2	47.0	26.45	83.8	22 21	1058	2.5	
11600	15 03.3	12.1	51.2	47.6	26.77	86.0	22 41	1057	2.4	
11700	15 15.4	12.2	52.2	48.3	27.08	88.2	23 00	1055	2.4	
11800	15 27.6	12.2	53.2	48.9	27.40	90.5	23 20	1054	2.3	
11900	15 39.8	12.2	54.2	49.6	27.71	92.8	23 39	1053	2.3	
12000	15 52.0	12.3	55.3	50.2	28.03	95.1	23 59	1052	2.2	8.3

The above range table was partially computed at the Artillery School by the class of 1896 as one of the practical applications of their ballistic studies. Their calculations were made with 400-yard intervals in the range (the argument of the table); and these intervals were subsequently reduced by interpolation and re-calculation, when necessary, to 100 yards. The data and normal conditions which were the basis of the calculations are given at the head of the table. The ballistic coefficient C was corrected for altitude for each range by the method of Problem XIII of the Handbook.

The table includes ranges up to 12,000 yards (6.8 miles) which is believed to be ample for all practical purposes, especially as the Buffington-Crozier type of disappearing carriage upon which these guns are being mounted is said to admit of only 12° elevation, which corresponds to a range of 10,000 yards. The second column of the table gives the angles of departure corresponding to the ranges in the first column, for normal conditions. But in laying the gun for a given range the tabular angle of departure must be corrected for jump, and for variations in muzzle velocity, in weight of shot and in atmospheric conditions,—if such variations exist and their magnitudes are known,—and lastly for wind effect, in order to determine the proper angle of elevation. These corrections are effected practically by the numbers in the third, fourth and fifth columns. The third column (d) gives for each tabular range the variation of the angle of departure for a change of 100 yards in the range. The fourth column ($\Delta'\varphi$) contains the variations of the angles of departure due to a variation of one-tenth of the value of the ballistic coefficient exclusive of the variation due to altitude, which was taken account of in constructing the table. The fifth column ($\Delta''\varphi$) gives the variations of the angles of departure (and practically also of the variations of the angles of elevation) produced by a change of 50 f.s. in the muzzle velocity. These several variations of the angles of departure will be either positive or negative according as the variations which produce them diminish or increase the range, which can easily be determined in each case. These variations are really first differences, and an examination of the table will show that *their* differences (second differences) are so small as to be practically insensible even when the variation of range is as great as ±200 yards.

The use of the table can best be indicated by a few examples.

Example 1.—What is the angle of elevation for a range of 3964 yards, conditions normal, jump 6′?

The angle of departure φ for a range of 3900 yards is, by the table, 3° 24'.5, and the variation of this angle for a variation of 100 yards is 6'.3. We therefore have, subtracting the jump,

$$\text{Angle of elevation} = 3° \ 24'.5 + .64 \times 6'.3 - 6' = 3° \ 22'.5.$$

Example 2.—What is the angle of elevation for a range of 6827 yards, temperature of the air 90°, barometer 30.16 inches, muzzle velocity 1924 f.s., and jump 8'?

From Table III of the Handbook we find δ_1/δ for the given atmospheric conditions to be 1.054, and therefore the variations of φ due to these conditions is 0.54 times the tabular value of $\Delta'\varphi$. To get the variation of φ due to the variation of the muzzle velocity we take $\frac{26}{50} = 0.52$ times the tabular value of $\Delta''\varphi$. We therefore have

$$\varphi = 6° \ 51'.7 + .27 \times 8'.3 - .54 \times 14'.0 + .52 \times 20'.6 = 6° \ 57'$$

and

$$\text{Angle of elevation} = 6° \ 57' - 8' = 6° \ 49'.$$

Example 3.—Suppose the actual range obtained by the shot of Example 2 was but 6754 yards, that is 73 yards short of the target. What should be the angle of elevation for the next shot all conditions remaining the same?

The falling short of the projectile in this example may be due to one or more of several causes. The muzzle velocity can seldom be known accurately at the beginning of a day's practice and there is always more or less uncertainty about the jump, and the force and direction of the wind toward the far end of the range. But if the loading be carefully and skilfully attended to we may assume, in the absence of any evidence to the contrary, that these conditions will be practically unchanged for the second shot. Now for an angle of departure of 6° 57' the table gives $d = 8'.3$,—that is, for the range in question, a variation in range of 100 yards corresponds to a variation of 8'.3 in the angle of departure (or angle of elevation, either) *when the muzzle velocity is 1950 f. s.* But this angular variation of 8'.3 is also practically the same for muzzle velocities varying either way from this by as much as 50 f.s.,—that is for muzzle velocities ranging from 1950 f. s. to 2000 f. s., as will readily be seen by making use of the values of $\Delta''(\varphi)$. The proper correction therefore to be applied to the angle of *elevation* is $.73 \times 8'.3 = 6'$; and this must be added to 6° 49' since the projectile fell short. The new and correct angle of *elevation* is therefore 6° 55'.

These examples it is believed indicate the following method for using range tables, especially for long ranges. To get the first shot as near the target as possible correct the tabular angle

for all known departures from the normal data upon which the table was constructed, such as for variations in muzzle velocity, atmospheric conditions and weight of shot, for drift and jump, etc. Then note accurately the error in range and deviation from the plane of fire. For the second and subsequent shots the angle of *elevation* should be corrected when necessary by the method of Example 3 which requires but a simple multiplication with subsequent addition or subtraction as the case may be, the whole occupying not more than a minute; while the correction in azimuth is easily made by well known methods. The variation of muzzle velocity, wind effect and jump are very difficult to determine accurately in advance; but unless they are abnormally large (in which case no accuracy of firing can be expected) it is not absolutely necessary to consider them at all, as the correction of the angle of elevation can be made even in this case with practical accuracy by means of the observed variation of range.

Example 4.—Suppose the 10-inch rifle to have been aimed for a range of 6000 yards in accordance with the range table,—no allowances having been made for wind, jump, possible variation in muzzle velocity, etc.; and suppose, when the gun was fired, the shot was observed to strike 150 yards over. What should be the angle of elevation for the next shot, all conditions remaining unaltered.

From the table we find for $X = 6000$ yards and $\Delta X = 150$ yards, $d = 11'.4$. Therefore angle of elevation for the next shot is $5^\circ\ 49'.4 - 11'.4 = 5^\circ\ 38'$. In our ignorance of the exact causes which made the shot strike 150 yards beyond the target we may for purposes of calculation assign either one of three causes: 1. A jump of $11'.4$, all other things being normal. 2. An increase of the muzzle velocity to 1983.5 f. s., with no jump and all other things remaining the same. 3. A suitable change in the value of C which can easily be computed. Of course the first view of the case is by far the simplest.

The variations in the times of flight and in the other columns of the table, accompanying variations of range, are of far less importance than variations in the angles of elevation, and for practical purposes need not be considered. The correction of elevation due to height of gun above the level of the sea has not been given in this table. If a sight embodying the principles of the Zalinski sight be employed this correction is made in the most complete manner by simply pointing the telescope to the target. If a table should be necessary for this purpose it would

naturally be prepared after the height of gun had been deter mined.

Captain JAMES M. INGALLS,
1st Artillery, Instructor.

THE BICYCLE AND ITS ADAPTABILITY TO MILITARY PURPOSES.

PART I. THE EVOLUTION OF THE WHEEL.

Introductory.

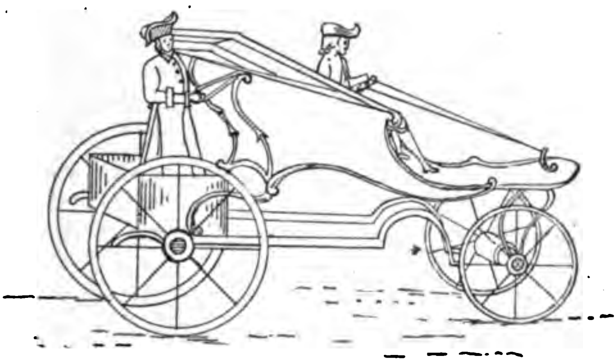
Perhaps the most remarkable feature connected with the history of the last decade is the wonderful interest taken in the bicycle, and the universal use made of this machine for purposes of business and pleasure. Fifteen years ago the number of bicycles in use in this country did not exceed a few thousand, and these were regarded as curious toys, and their riders as "gentlemen of leisure," hard up for some amusement. To-day a conservative estimate would put the number of wheels *in use* in the United States alone at not less than one million, and of these by far the greater part are employed as a substitute for walking, the street car, or other method of transportation, in the business of everyday life.

The bicycle illustrates perhaps better than any other single product the enormous strides made in these *fin de siècle* days in the mechanical arts, and the rapidity with which every improvement is tested and put to practical use. It is doubtful if there is a single other machine in which lightness, ease of running and great strength under widely different stresses are so essential to its success, or have been so thoroughly worked out in its construction; and it may be a matter of just pride to the workman returning from his daily task to know that he is riding a vehicle that fifty years ago not all the talent and not all the money in the world could have procured.

"History repeats itself" in the matter of inventions as well as in other things. It often happens that the conception of the inventor has preceded the possibility of the success of his invention by many years, and the thought lies dormant, neglected or forgotten, until progress in the arts has brought into existence new materials, improved the quality of the old, or cheapened the cost of production to such an extent that the invention can be practically realized. This has been the experience of nearly every beneficent invention, and the bicycle forms no exception to the rule; for one of the earliest types of bicycles ever designed was of the rear driving safety pattern, closely resembling in its general features the ladies' wheel of to-day; but the state of the

arts at that time did not permit the building of a successful machine, and subsequently, when the matter was revived, the stream of invention was turned into the simpler channel of construction shown in the old style front driving bicycle.

Initial period, 1750-1865.—Just when the idea of travelling by leg-power assisted by wheels, originated nobody can tell, nor is it known who was the author of the notion. But the first published accounts that we have on this subject were embodied in a description of "Ovenden's Machine," in the *Universal Magazine*, an English publication, in 1761. This machine, a cut* of which is here reproduced, was a four-wheel vehicle which from its



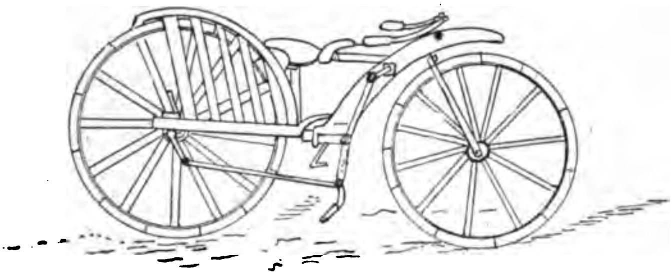
appearance must have weighed well nigh 500 pounds; yet the sanguine inventor, we are told, "expected the unfortunate footman (whose overworked legs are mercifully hidden from view in a sort of tank) to drive that immense wooden carriage and its contents 'with ease' six miles an hour, and 'by a peculiar exertion' nine or ten miles per hour." As nothing further is known of Mr. Ovenden or his engine, it is suggested that he fell a victim "to a secret assassination committee of footmen." It is worthy of notice that, if we removed the footman from the tank, and in the place of the treadle which he was supposed to operate supplied a petroleum or storage electric motor, we should have a very fair representation of the general appearance of a number of the recently invented motor wagons.

As the motor wagon is coming into great prominence, and promises to have an important bearing on military transportation, I shall briefly refer to it here, in connection with the developement of the bicycle (which historically it preceded), as well as, subsequently, touch upon the bearing which it may have upon military cycling.

* Reproduced from *Strand Magazine*.

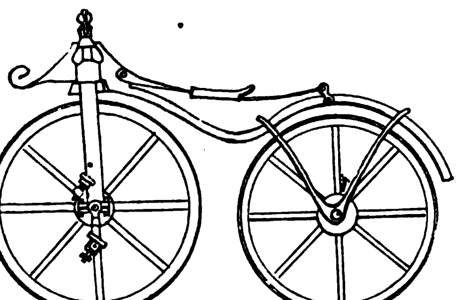
Ovenden's machine had many imitators, as the records of the patent offices at home and abroad abundantly prove. Some of these were designed to be propelled by a treadle and crank, as in the case described, others by hand through a winch and train of gear wheels; and it would seem that he was the most sanguine inventor who could manage to introduce into his machine the greatest number of complicated gearings. While all of these efforts were failures, and many even in their day must have appeared grotesquely absurb, there were not lacking inventors of merit who still persisted, in the belief that the problem of the self-propulsion of a man in his own carriage was capable of a practical solution. Clearly the first step was to reduce the weight, and this was partially accomplished in the tricycle three points of support being considered necessary for the sake of stability. These machines were all driven by means of gearing connected with the main wheels or "drivers." In 1808 there was brought out in England a machine of a different class—a new kind of "hobby horse." This invention consisted of two wheels connected "tandem" by a rigid frame of wood. A seat was provided midway between the wheels, and the rider, mounting astride his "horse," urged it forward and at the same time maintained himself and machine erect, by means of vigorous kicks, skillfully administered to the ground. As the two wheels were rigidly constrained to rotate in the same plane, it is obvious that motion was practically limited to a straight line; and when the rider wished to change his direction, it was necessary for him to lift his vehicle bodily and plant it in the required plane. This inconvenience was remedied by mounting the front wheel in a fork, which permitted lateral movement about a vertical axis; and the "dandy horse" thus resulting became a great fad among English noblemen about 1820. The "dandy horse" may be considered the progenitor of the modern bicycle, though the principle for maintaining one's balance, as we know it, was not understood. About 1834 however, Gavin Dalzell, a native of Lesimahagow, Scotland, brought out a bicycle, a cut of which is here reproduced, which bears a striking resemblance to the modern safety bicycle. This was the machine referred to on the first page of this article. It will be seen that this remarkable machine was fitted with a handle bar for guiding, a crank for propelling, and a mechanism for communicating power to the rear wheel.* The seat was placed well back, and a little in rear of the vertical through the crank axle as at present and the

* Reproduced from *Strand Magazine.*



wheels did not differ much in size from those of to-day. But the frame was heavy and clumsy, the principle was new, and it is probable that the hills of Scotland and the close-grained, shrewd but narrow sense of the Scottish people gave the inventor little encouragement. Certain it is, his invention never attracted much attention, and only came to light in recent years after the problem which he had so nearly solved had been worked out by other hands in another country.

Period of Transition, 1865–1893.—To Pierre Lallement—a French mechanic—is justly given the credit of having produced the first practicable two-wheeled, crank-driven, man-propelled vehicle; his machine,* brought out somewhere about the close of our Civil



War, consisted of two wooden wheels, tired with iron bands, and in general make-up similar to the carriage wheels of that day; the front wheel, some fifty inches in diameter, was provided with a pair of cranks and pedals for driving, and was attached to a fork. The latter was equipped with handle bars for steering, and supported the "back bone" which in turn was attached to the frame work carrying the rear wheel. The wheels were thus joined up tandem, and the back bone was depressed slightly between them, over which depression was stretched tightly a band of steel to which was attached a piece of leather making

* Reproduced from *Strand Magazine*.

the "suspension saddle." This two-wheeled truck, or "velocipede," as it was called, weighed about one hundred pounds and as it went jolting and wobbling over even the smoothest pavements, it must have been a far greater source of curiosity to the public than of comfort to its rider. Still, it would work; and in the enthusiasm which followed its advent a good many differing but slightly from the original were made and disposed of. A model of Lallement's velocipede was exhibited at the International Exposition, in Paris, in 1869, when it attracted much attention. To this fact is probably due the many imitations that appeared soon after in other countries. The problem had been solved, theoretically not so well as it had been done thirty years previous by the Scotchman Dalzell, but practically with far greater success. And the beautiful type of our present safety, much as it differs from its prototype, must be considered the direct and legitimate descendant of the "bone shaker" of Lallement.

The success of Lallement's machine was a great spur to invention, and the designing of new bicycles and the improvement of those in existence became a favorite object for the ingenuity of the inventors. Especially was this true in America, where the skilled mechanic and the uneducated "Yankee genius" seemed to vie with each other. And while the thread of uniform improvement may be clearly traced from now on, there were many ravellings of truly strange and startling character,—enough indeed, to fill a volume. We may briefly mention a few of these as examples.

A citizen of Buffalo designed a four wheeled vehicle to be driven by a pair of spaniels enclosed in a revolving cage like that used for pet squirrels.

Mr. Ward of New York designed a monocycle, consisting of a wheel of large diameter, to the axle of which were attached pedals, and a fork carrying the rider's seat. The fork projected below the axle about one foot, and terminated in a counterpoise to maintain the rider erect. It is apparent on consideration of the inequality of the lever arms, that the counterpoise must weigh somewhere about five hundred pounds. But this consideration does not seem to have deterred the inventor.

Perhaps, however, the design that would find most favor with us, had the sanguine expectations of its inventor been realized, was that of Mr. Gleason, which appeared about this date. This gentleman, recognizing the poor quality of our roads, proposed to carry his highway, so to speak, along with him. To fulfill this

apparently difficult condition, he designed an endless belt of wooden slats, like the floor of a tread mill, which was to envelop the two wheels of his vehicle (being held in place by suitable flanges) and so arranged that each slat should be laid successively for the front wheel to pass over, and taken up as soon as the rear wheel had left it. It is safe to say that this design never got beyond the experimental stage.

Turning from these ephemeral productions, we shall now briefly sketch the most striking features in the development of the wheel.

The first step was to relieve the horrible jolting of the "bone shaker," and this was partially accomplished about 1870 by the invention of the well known "solid rubber" tire, and the introduction of various springs in the frame. Metal spokes and hubs soon took the place of the wooden ones, and iron tubing replaced the parts of the wooden frame. At about the same time, the cylindrical bearings gave place to adjustable conical ones, which in turn were soon followed by the now familiar ball bearing, the most perfect anti-friction device known.

In 1874, M. Merchegay, a French engineer, published an essay upon the bicycle, wherein he showed that weight would be reduced and ease of running facilitated by giving to the front wheel a large diameter, reducing the diameter of the rear, and mounting the rider as nearly as practicable over the axle of the front wheel. These ideas were carried out in practice and this wheel became the favorite mount. This type of machine was exhibited at our Centennial Exposition, 1876, and for several years it maintained its ascendency—improvements being chiefly confined to lessening its weight and draft.

We are now at the period of wheel construction described in the latest edition of the *Encyclopædia Britannica* (1882) where we read, as a summary of the most recent progress in bicycle construction, "and nowadays, a crack racing bicycle with a driving wheel of 55 or 60 inches in diameter does not exceed fifty pounds in weight, or about half the weight of the old wooden machine." This "crack racing wheel" referred to as so light, was the familiar "ordinary"* bicycle—so named before the safety type had come into general use.

The Ordinary, above described, was a good machine, simple in construction, popular in its day, and capable of doing efficient road service, as is evidenced by the fact that it has been taken

* The word "ordinary" applied to the high, front driving wheel is very misleading, but will probably stick. The French have a better nomenclature; our "ordinary" is their *velocipede*, and our "safety," their *bicyclette*. Any intervening type is called *bicycle*.

aud ridden in all parts of the world. But the rider was seated so far to the front that the centre of gravity was but a short distance in rear of the point of support of the forward wheel, the result being that a sudden checking of the speed, as in passing over an obstacle or upon the application of the break in coasting, would cause the rider to pitch off forward, or "take a header," while the saddle was so high above the ground that such an adventure was peculiarly dangerous. Various expedients were adopted to remedy this, perhaps the most common being to place the small wheel in front of the driver; but this, while lessening the the chance of fall, did not diminish the serious consequence of it, and in spite of all, a rider, be he ever so careful, would sometimes get a tumble. These conditions therefore gradually led to the downfall of the Ordinary, and the substitution in its place of the so-called "safety bicycle", of which there are two distinct types.

First, the "front driving safety," or as it is usually called, the "geared ordinary." In this machine, the front wheel remains the driver, but it is reduced considerably in diameter while the rear wheel is correspondingly increased; at the same time the saddle is removed farther to the rear and adjusted to the rider's height. In these respects it more nearly approaches the line of the old velocipede. The power is applied to the forward wheel through cranks and pedals, as before, but these, instead of directly producing rotation, are geared into a hollow shaft concentric with it, in such a manner that for a given angular velocity of the pedals, the velocity of the bicycle is brought up to at least that of an "ordinary" of suitable diameter for the rider. There are many modifications of this type of wheel. This machine has not been much used in this country, but abroad it is said to have once been a popular mount.

The *second* class of safety bicycle is the "rear driving safety" (or simply "safety") so familiar to us all. This wheel originally known as "the Rover" type, was brought out in England in 1884, and soon after was introduced into other countries.

In the earliest types of this machine the wheels were of unequal diameters the front wheel being the smaller; in the succeeding models, however, as a rule, the two wheels were made of equal diameter (about 32 inches), and the seat, pedals, chain and handle bars were placed in about the same relative positions as in the present form of safety. The lines of the frame were however very different, the chief support being derived from one main piece attached to the fork at the steering head, and

running diagonally downward, forking so as to embrace the rear wheel, to which it was connected through the axle. At this rear fork head was attached a transverse piece of tubing in the plane of the wheels, the upper portion curving to the rear and supporting the saddle, while the lower portion supported the casting carrying the axle; two tension rods, connecting either end of this transverse arm with the steering head, completed the frame.

The great superiority of this machine over the Ordinary in point of safety and convenience soon became manifest, and its advent marks a new era in bicycle development. Cycling took a "bcom." The makers of the old style Ordinary soon took the cue, and transformed their factories in order to turn out the new invention, while new companies took the matter in hand, so that the popular demand and the spur of competition, reacting upon each other, led to a progressive improvement of wonderful rapidity. Particularly is this true between the years 1888 and 1894, where each season marked almost an entirely distinct machine, immensely superior to the preceding year's product. These improvements may be briefly sketched as follows:

1st. Changes in the tires.—The small solid rubber tires were not sufficiently resilient, and in order to alleviate jolting and save the machine in passing over rough ground, manufacturers were compelled to introduce springs, giving rise to the various "spring forks," "spring frames," etc., so common about 1890. These were objectionable, not only because they increased the weight and provided joints that were always working loose, but also because a considerable portion of the thrust applied to the pedals by the rider was taken up in a useless compression of these springs, instead of being properly transmitted through the chain to the driving axle. It was evident that the real place for improvement was in the tire, in order that the shock due to an obstacle might be instantly taken up without being transmitted to the frame. The first real improvement came in the adoption (in 1890–91) of the "cushion" tire, in which the diameter of the tire was increased to about an inch and a half, and the tire pierced longitudinally by a hole of about one-third its diameter. The resiliency of the tire was much increased, but it still depended, however, upon the elastic qualities of the rubber. This form of tire was improved upon by using a rubber arch in the form of an inverted letter U—the sides being held in place by flanges on the rim,—giving better results, with less weight.

But the invention—or rather application—of the "pneumatic tire" in the succeeding year, proved to be a triumphant solution

of the problem, and constitutes without doubt the greatest improvement in the construction of the bicycle since the appearance of the original "bone shaker." The credit for this great improvement is given to an Irish veterinary surgeon—Dunlop—who revived a long forgotten English invention.

The pneumatic tire is essentially an air-tight annular ring of circular cross-section encircling the rim of the bicycle wheel, to which it is secured by cement or some mechanical means. It is inflated with air, the pressure used varying from 25 pounds to the square inch to 70 or 75 pounds, depending upon the nature and size of the tire, weight to be borne, the character of the road, and the purpose to which the wheel is to be put. Hence, a knowledge of a correct adjustment of the pressure to these ends is needful both for ease of riding and for the preservation of the wheel. The extreme pressures are used by racers riding over very smooth roads, an exceedingly elastic and resilient tire being found best for speed.

The action of this tire is readily understood. Thus when the wheel strikes some small obstacle, the tire yields locally, transmitting the resistance through the elastic medium of the compressed air, and distributing it uniformily over the entire rim, while the center of gravity of the machine is not appreciably raised, and the bicycle in consequence experiences but little shock. It is light, yet offers a wider tread, enabling the wheel to pass more easily over rough ground, and be less liable to slip on a slippery pavement.

The lessening of the shocks to which the former tires exposed the wheel has been one of the chief factors in the great reduction of weight made in the up-to-date bicycle.

This tire has been much improved since its first appearance in strength, resiliency and durability; and the liability to puncture, which is the chief objection urged against it, has proved to be not nearly so great as was at first anticipated, while on the other hand the adoption of numerous ingenious devices, has made possible the quick repair of the punctured tube. It is this consideration which gives rise to the chief varieties. Without going into the details of construction, which would fill a volume, we can broadly distinguish two classes of pneumatic tires.

1. The "single tube tire."—A section of this tire shows as follows, starting from the outside: 1st, a layer of vulcanized rubber, made thicker at the "tread;" 2d, a layer of canvas, or fabric, to give the tube the necessary strength, especially that

required to resist the bursting effort of the confined air; 3d, a layer of pure gum rubber, air tight, which so long as it remains intact will prevent the leaking of the gas, no matter how much rough usage the tire receives. These three layers, in the operation of manufacture, are cemented together so as to form one substantial whole. The repair of a perforated single tube tire is now a simple operation; as soon as the puncture is located, it is cleared and smoothed by means of a suitable tool, some rubber cement is then uniformly spread over the inner surface and around the stem of an umbrella shaped patch of pure gum rubber, the patch, stem up, is pushed through the prepared puncture by means of an inserting tool, then grasped by the stem and twisted around three or four times, so as to distribute the cement evenly upon the inside of the tire around the puncture, whereupon it is pulled up tightly by the stem, causing the patch to lie flat and snug against the smooth surface of the tube. The tire is then inflated, so as to bring a light pressure to bear upon the patch, and is allowed to remain that way for a few minutes to allow the cement to "set," when it is inflated with the full riding pressure, and the superfluous stem of the patch is trimmed off even with the tire. As a temporary expedient on the road, a piece of "tire tape" may be wound about the tire, covering the puncture, or a piece of adhesive plaster may be bound on, or many other simple expedients resorted to.

2. The "double tube tire."—This tire is composed of an "outer case" and an "inner tube;" the outer case is made of vulcanized rubber and canvas joined together as above, and the inner tube is of pure rubber, air tight, but separate and removable from the outer case. In case of puncture, the inner tube is removed from the outer case, the puncture located, and a piece of thin gum rubber cemented over it; the tube is then replaced, and the wheel inflated. The chief variations arise from the methods used to get at the inner tube. Thus, in one type the outer case is shaped like the letter Ω and is secured to the rim by suitable flanges, etc., and held in place firmly by the air pressure; this is known as the "clincher" tire; the inner tube in this case is continuous. Upon puncture the portion of the outer case in the neighborhood of the puncture is displaced from the rim, and the inner tube is drawn out through the opening and repaired. In the second form the outer case has a circular cross section, like the single tube tire, and is cemented like it to the rim. Here the inner tube rectified is a cylinder a little longer than the mean circumference of the outer case, and is closed at

each end. It is inserted and removed through a longitudinal slit in the outer case, made on the surface adjoining the rim, the outer case being rolled off from the rim at this place to permit this operation. In its insertion, a string, weighted at one end, is let around through the outer case, the other end is attached to one end of the inner tube, which is hauled around by this means to its place. The greater length of the inner tube allows its closed ends to lap, so that upon inflating they mutually support each other. When the inner tube is in place, the slitted outer case is laced together, and that portion of the tire recemented to the rim. In another form, the outer case is parted and laced together along its entire least circumference, so that in case of puncture, it is only necessary to break from the rim the portion in the immediate vicinity, which when unlaced exposes the inner tube for repairs. Another successful modification is as follows; an opening is made through the rim, and immediately under it one in the outer case, through which the inner tube may be withdrawn at pleasure, repaired, and inserted by means of a string, weighted at one end (as before described), without the necessity of removing the outer case from the rim.

Probably the most successful scheme for quick repair yet devised is that brought out in this country.* The outer case is of the laced type, first described, but the inner tube is novel. It presents the same external appearance as the old style closed cylinder tube before described, but in addition it has a flap or web of thin rubber attached to it by the edges, on the inside, on that portion which lies next to the rim. When the inner tube is inflated, this flap simply remains in place. In case of puncture the operation of repair is very simple. The hole is cleared as described for the single tube tire; next a little rubber cement is injected through the hole and distributed uniformly so as to cover that portion of the flap immediately opposite the puncture. The exhausted tire is then pushed down towards the rim, so that the hole in the inner tube is covered by that portion of the flap to which the cement has been applied, and held there for a moment for the cement to "take;" the tire is then inflated as before. It is said that a perfect repair can be executed by this method in from two to five minutes.

It will be observed that this device contains the good features of the method of repair for the single tube tire with the advantage of allowing one to withdraw the inner tube when the former method proves unsuccessful.

* The "Morgan and Wright" quick repair inner tube.

THE ROVER.

In addition to those described, pneumatic tires have been made that are practically unpuncturable—such as, for instance, will turn the point of the sharpest pin or thorn, and through which a knife blade, or sharp awl can be forced only with difficulty. These tires, however, have not so far been widely adopted, probably because the indurated fabric of which they are made is not as pliable as that of the usual tire, so that there is a loss of resiliency and consequent ease of running; while on the other hand the quick repair methods above referred to satisfy the ordinary rider who seldom meets with a puncture.

We have gone into this subject at considerable length for it is one of the greatest importance. The tire to a bicyle is what the shoe is to a man or horse, and a poorly "shod" wheel is likely to produce constant trouble, and finally cause the machine to break down altogether.

We shall have occassion to consider the matter in another light when we come to a discussion of *military* wheels.

3. Changes in the lines of the frame, and dimension of the wheels.—The original Rover frame was not a strong one, as is apparent at a glance, and it was soon practically abandoned. The frames designed to take its place, however, though built on the plan of a compound girder or truss, were exceedingly dissimilar, each manufacturer having a distinct model of his own, and building his machine upon those lines. The quite general use of springs added to the dissimilarity. The diameter of the wheels too was an unsettled matter, some making the driver the larger, others the smaller, while many made both the same size, and they ranged all the way from 34 inches to 26. All machines were provided with mud guards, breaks, chain guards, etc., and comparatively little attention was paid to the matter of weight—a wheel weighing from 60 to 65 pounds being not unusual. But as season followed season the experience gained each year was used in the betterment of the next season's product and while the number of manufacturers continually increased from year to year we find the different makes more and more nearly approaching each other in general features, until, just about the time that the introduction of the pneumatic tire made the discarding of all springs and spring frames a possibility, the matter of the proper frame had been settled by the almost universal adoption of the beautiful, straight line, pentagonal truss, known as the "single diamond," or Humber frame. In the meantime there had been a constant demand for a lighter bicycle on the

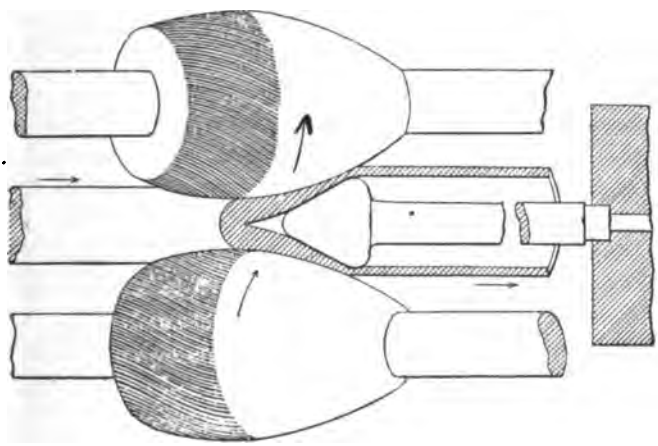
part of the public, and although the older manufacturers were inclined to be conservative in the matter of weight reduction, they were forced to comply by the competition of the younger manufacturers, who taking this as their cue, sought to gain the popular favor. Each year saw a substantial lopping off of weight, and yet there was no apparent loss of strength; on the contrary, in many instances, there appeared to be a substantial gain. Needless parts, such as mud guards, chain guards, etc., were discarded entirely, and parts that before had been made unnecessarily strong and heavy, were trimmed down—solid parts being replaced by hollow ones wherever possible. The pneumatic tire, by its far greater elasticity and buffer power, permitted the reduction of the wheels to what now appears to be everywhere the standard diameter of 28", and likewise lessened the weight necessary for the frame. Finally, improvements in the materials used, and improved methods of assembling, as we shall see presently, contributed to the same end. Thus it is that in the five years between 1889 and 1894, we find the standard road machine reduced from 60 and 65 pounds to about 25 pounds, the light roadster to 22 pounds, and the racer to 19, 18 and even 15 pounds.

4. Changes in materials and methods of manufacture.—Progress has been very great in these respects. Wood has given place to iron and iron to steel, and cast metals to forged and drawn metals of wonderful strength and toughness. The great advance made in the treatment of steel is nowhere better exemplified than in the bicycle.

Complex shapes that were once thought impossible to produce except by casting, are now forged out with ease, and turned down to finished dimensions by engines that are marvels of accuracy and ingenuity. Great improvements have been made in brazing together the component parts, and the joints can no longer be considered weak points in the frames. The system of gauging now everywhere adopted, rejects all misshapen pieces and secures interchangability of parts.

The most notable improvement however is in the quality of the steel tubing brought about by the Mannesmann process. In the original process of manufacture of seamless steel tubing, a steel ingot is forged into a cylindrical form, bored, and then drawn cold successively through taper dies of gradually diminishing size, and over a mandrel of appropriate form. As in the case of wire drawing, the tubes assume a fibrous structure, and have to be often annealed to prevent brittleness. While by

careful manipulation this process will produce tubes of excellent quality, and of great tensile strength, they are liable to variations due to ununiform or imperfect annealing, or to other causes, and do not seem so well suited to withstand compressive or cross stresses. In the Mannesmann process, on the contrary, a *solid* cylindrical ingot of steel is brought to a *bright red heat* and placed between two conoidal rollers of peculiar form, whose axes are inclined to each other, and make equal angles with the axis of the ingot. The ingot is free to rotate on its own axis, and in addition can be given a controllable longitudinal motion. When it is considered that the same piece of a bicycle frame may be called upon to withstand any of these strains it is seen how well adapted this tubing is to the needs of the bicycle. The rear portion of the rollers are striated, so that they bite into the soft (heated) metal of the ingot, and, while causing the ingot to revolve about its axis, at the same time exert a longitudinal pressure upon it causing the surface to advance relatively to the interior, and leaving therefore a hollow space within. A mandrel of suitable form is inserted in this opening, and serves to guide the tube, while at the same time smoothing and shaping the interior. The accompanying cut, taken from the *Revue d'Artillerie*, will serve to make the above incomplete explanation more clear.



There results from this that the tube has a spiral fiber, like "the twist" of a gun barrel, and while very tenacious, is equally adapted to resist compressive or cross stresses. This is made evident from the following, quoted from the *London Engineer:*

"A strip cut parallel to the axis of the tube* gave the following

* A 4''.45 tube was tested, but the results will serve to illustrate the properties of the metal.—*Engineer*, vol. 69, p. 516.

results: Breaking strain, per square inch 35 tons (78,400 lbs.); elongation 25% in 8 inches; contraction of area, 54.2%.

If the metal is homogeneous throughout, well rolled, and carefully heated, it makes a perfect tube, or at any rate a near approach to it; but if there is any flaw in the bar, or if the furnace man has been careless in the heating, then the Mannesmann rolls reject that bar, by refusing to make a tube out of it, more sternly than the severest human inspector would. When the tubes give way they do not break, but bend, and even when they are completely crumpled up they do not burst or crack."*

Another advantage which this kind of tubing permits is that the thickness of the metal may be absolutely regulated, without changing the exterior diameter, so that the tube may be duly proportioned to withstand the variable stresses upon it; I do not know, however, that this fact is taken advantage of in bicycle construction.

The frames of a large proportion of the best bicycles are now built of this kind of tubing.

An advanced step has been taken by at least one manufacturer† in the employment of tubing made of nickel steel, allowing, it is said the use of a higher percentage of carbon, thus increasing the elastic strength of the tube, without impairing the ductile qualities of the metal upon which the safety of the rider depends. A complete frame, built of this tubing for road use is said to weigh but three and one-half pounds.

For many years the eyes of the public have been turned towards aluminium as the "coming metal," from the low specific gravity of which much has been hoped in the building of machines where extreme lightness and strength are essentials. Many attempts have been made to construct bicycles of aluminium, which have proved expensive failures, for the metal itself is inelastic, weak and brittle, and is not capable of being welded or brazed, in fact possesses with the single exception of lightness, the very qualities to make it unsuitable for bicycle construction. But as pure iron (or as near as we approach it in the commercial wrought iron) is too soft and inelastic for a good bicycle material, yet upon the addition of proper elements, such as manganese,

* "The tubes obtained by the Mannesmann process offer a much greater resistance than those obtained by any other method of fabrication. A tube of 30 mm. (1''.20) caliber and 37 mm. (1''.48) exterior diameter proved in a hydraulic press resisted permanent deformation up to a pressure of 1700 atmospheres (about 25,000 pounds per square inch). This pressure, it is seen, on the application of Lamé's formula, corresponds to a tension of 82 kg. per sq. mm., (116,600 lbs. per sq. in.)".—Moch.

† The Pope Manufacturing Company.

nickel, and above all carbon in the right proportions, and subjected to proper manipulation, is turned into steel, a metal differing entirely from its chief constituent, so too it has been thought that some alloying substance might be found to give to aluminium a suitable "temper," yet not added in sufficient quantities to materially increase the weight of the compound over that of the original substance.

Such an alloy, it is claimed, has been found, and now for the third season is being put successfully into the construction of bicycle frames. It is called "Luminum." The alloying substances and the mode of manufacture are kept secret. Its properties are best set forth in the catalogue of the manufacturers,* from which we quote:

"Luminum is an alloy consisting of about 96% purest refined aluminum and about 4% of other substances, the whole combined and treated by an entirely new process, both chemical and mechanical. The result is a metal which is, bulk for bulk, about the same strength as the best wrought-iron and only one-third as heavy. Weight for weight our metal shows about double the strength of any steel that can be made up into cycle tubing and brazed together, and it actually shows a higher tensile strength and modulus of elasticity, weight for weight, than any steel."

Other advantages claimed for their alloy are: Freedom from crystallization due to vibration; freedom from oxidisation; and the possibility of making the frame complete of one piece, by molding, instead of building it up and brazing together the component parts, thus securing a more rigid frame, and as the frame is bored for the bearings after casting, the alignment of the parts must be correct. The following figures are given, as the result of a test of three specimens made by Professor J. B. Johnson, Washington University, St. Louis:

Length of specimen, ten inches.

Cross section area, one square inch.

Ultimate tensile strength (average), 24,600 lbs. per square inch.

"The average permanent set (stretch) of these specimens before rupture occurred is one-half of one per cent (½%).

The metal is therefore almost perfectly elastic up to the point of rupture."

Taking the ratio of specific gravity of steel to that of luminum as $7.8/2.7 = 2.9$, let us compare these figures with the

* The St. Louis Refrigerator & Wooden Gutter Co., St. Louis, Mo., 1896, Catalogue of Luminum Bicycles.

corresponding ones in the case of the Mannesmann tube cited. We see that the elastic strength of a luminum specimen of weight equal to that of a corresponding specimen of steel of the same dimensions as those tested by Prof. Johnson would be 24, 600 × 2.9, or about 71,340 pounds to the square inch, a result that does not differ so very much from that obtained from the test piece from the Mannesmann tube. With no other data at hand the inference is that the luminum frame would prove the stiffer and more elastic up to the elastic limit, when it would part by a sudden break, while the superior ductility of the Mannesmann tubing would prove of advantage in allowing the frame to yield considerably before breaking in case of accident, supposing, of course, equal weights of metal similarly distributed in the two frames.

PRESENT PERIOD OF CYCLE CONSTRUCTION.

With the introduction of the pneumatic tire and the Humber frame, we enter upon a new period of cycle construction, a period of no radical changes from year to year, yet nevertheless one of progressive growth. For the past few years it has been the custom of dealers both at home and abroad to exhibit in some principal city the leading bicycles and cycling novelties which they expect to put on the market for the year, and in this way a visitor can soon discern what are the main steps in advance over the preceding year. Generally speaking the chief changes up to date have been as follows: 1st. Making several different heights of frame, to better accommodate riders of different length. This is both stronger and more elegant than the former practice of making the frame for the shortest rider, and using a long saddle-post for the taller. 2nd. Increase in the diameter (with reduction of thickness) of the tubing of the frame, giving greater strength with the same weight of frame. 3rd. Increase in the size of the balls and diameters of the ball racers, thus reducing friction. 4th. Improvements in the fabric of the pneumatic tires to increase resiliency and strength. 5th. The quite general introduction of the wood rim for all wheels. 6th. "The narrowing of the tread;" i. e., diminishing the distance between the cranks so as to give the rider a more direct thrust upon the pedals.

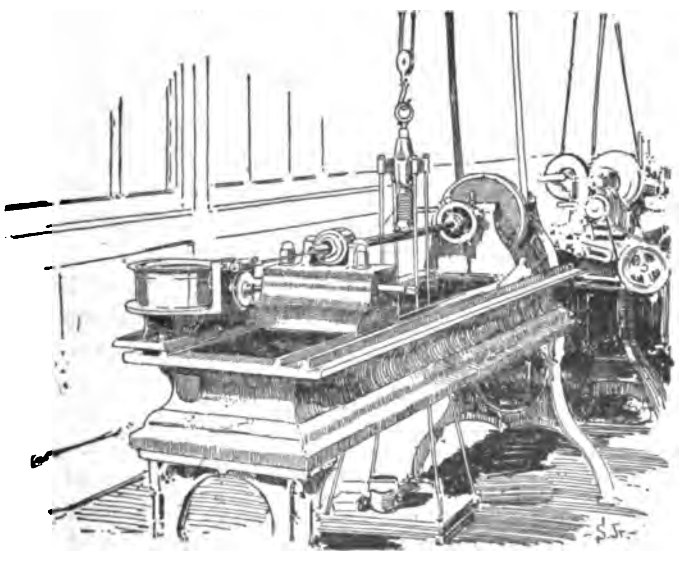
The tendency of most of these changes has been to reduce weight, but it would seem that the limit of reduction is about reached.

Indeed, it is only by exercising the greatest care in the methods of manufacturing, and subjecting each part to careful

Model of 1896, Remington racer; weight about 18 pounds. Cut furnished through the courtesy of the Remington Arms Company.

inspection that this extreme lightness has been maintained; and the various parts that enter a bicycle are in the best equipped factories tested and proved almost as carefully (both chemically and mechanically) as in the building of a twelve-inch gun. The period of guesswork is now past, and no change in the future will be made unless it seems theoretically advantageous, and is confirmed by actual experiment before adoption.

We give here two cuts (furnished through the courtesy of the Pope Manufacturing Company) of testing machines used in the testing of Columbia bicycles. The first is for testing tubes for



alternate stresses; the tube is inserted in the lathe, and as is seen from the cut, each revolution of the spindle causes a double vibration of the tube. In the second cut, a bicycle wheel is represented, carrying a load of 200 pounds applied through the weighted lever, under which the large under wheel, provided with "humps" of varying size and shape, is made to revolve to represent a road velocity of 13 miles per hour. In this way the endurance of wheels for rough riding is accurately determined.

OTHER TYPES OF BICYCLES.

So far we have spoken of wheels designed for single riders, and among them those for men only; in addition, most companies (in the United States at least) manufacture a looped model for the use of women, which, however, cannot from its form ever approach the model for men in point of strength.

Other machines are also built on the same general lines as the safety to accommodate two or more riders. Of these the "tandem" is the only one in much use. This has hitherto been principally used for track purposes, it being possible to get a higher speed from it than can be attained by the efforts of the single rider. At present it seems to be coming more into popularity as a wheel for social use. The illustration below (cut furnished through the courtesy of the Remington Arms Company) may be taken as a good example of the up-to-date machine of this class.

Remington tandem; weight, about forty pounds.

Bicycles of the same type provided with three, four and even six seats (triplet, quadruplet and sextuplet) are also built, but only for purposes of racing. A "sextuplet" recently exhibited at the New York cycle show, is geared to great speed (gear 153), and the designer expects it to bring down the record of speed to within the "mile a minute" pace.

THE MONOCYCLE.

Many efforts have been made to make practical use of but a single wheel. We have already referred to the one proposed by Mr. Ward; and many of us have seen "trick" riders maintain their balance on one wheel. The latest idea has been to place the rider inside the large wheel, which he drives by some sort of epicyclic gear. The difficulty of mounting and steering this vehicle, and the awkward position of the rider has rendered all of these vehicles of no practical value.

Imlah Wheel.—Cut from photograph taken by the author from *Scientific American*.

THE MOTOR WAGON AND MOTOR CYCLE.

The great success achieved with the bicycle has lately led to the revival of interest in the "self-propelled vehicle" usually called the motor wagon. Traction engines have been used on the high ways for years, for the hauling of themselves and portable machinery, but the idea of the motor wagon is different, being to obtain a vehicle of relatively fast speed, for use on the streets and highways, either for the delivery of parcels, etc., or for the conveyance of people. Many machines have been built and tested within the last two or three years, and while it cannot be said that complete success has been achieved in any one pattern, there has been enough to encourage the belief that the problem will be definitely and satisfactory solved in the near future.

The motor wagon usually resembles an ordinary carriage, without the horses and poles. The wheels are quite generally made ball bearing and equipped with pneumatic tires. For purposes of speed it is essential to keep down the weight as much as possible, and the designing of motors of special lightness for this purpose has been the object of inventors for a number of years. Herein may be said to reside the characteristic features of the various machines.

Generally speaking there are four classes of motors proposed: 1st. The steam engine. 2d. Gas engines. 3d. Coal oil and gasoline engines. 4. Electric motor, fed from storage cells.

Last year there was a competitive road test between Bordeaux and Paris, in which all machines were free to enter. Although there were a number of entries only two completed the entire journey. These were gasoline engines. A more recent trial was arranged to take place November 2d, in Chicago, and actually held Thanksgiving Day (November 28). The following account we glean from *Engineering:*

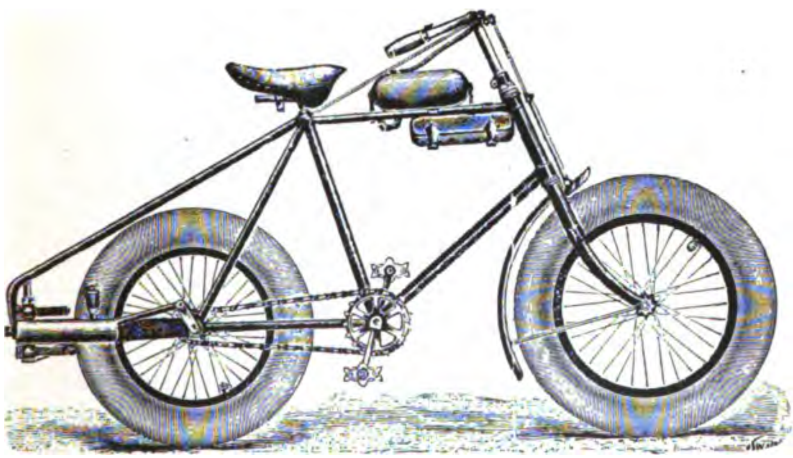
The number of entries originally made was about ninety, but the practical machines entered and those actually built for the competition numbered probably less than a score. About a dozen were entered for the trial, but of these only six started, and of these six carriages, two made the entire trip, one nearly completed it, and the other three withdrew after making short runs. It must be remembered, however, that some of the carriages that failed to start for the competitive run for various reasons are practicable and commendable machines, which have been used more or less extensively by their owners and builders.

The route was generally level and the streets well paved with

wood, asphalt or macadam. A heavy storm of wet sticky snow, prevailed a day or two before the trial and the road was covered with snow and slush to a depth of about six inches, being thus in very bad condition for carriages with or without horses.

Of the six entries, actually contesting, four had gasoline motors, and the other two were of the storage battery system. The two that completed the journey were of the gasoline type. The following is the record of the winner, with a brief *résumé* of its performance: Distance, 54.36 miles. Total time, 10 hours and 23 minutes. Running time, 7 hours and 53 minutes. Average speed, miles per hour, 7.

The carriage making this performance is known as the Duryea. It is a four wheel vehicle, with a gasoline motor of 4 horse power, and weighs about 1000 pounds. It is said to have attained a speed of 16 miles per hour, on good roads. It carries a supply of gasoline sufficient for about 100 miles. The engine consumed three and one-half gallons of gasoline, and 19 gallons of water *en route*. The price quoted ranges from about $1,000 to $2,000.



Cut furnished through courtesy of *American Machinist*, N. Y.

The motor principle has also been applied to tricycles and bicycles with encouraging results. Perhaps the machine that has the most promise is that known as the "Kane-Pennington Motor Cycle." This machine, here illustrated, is built on the lines of the safety bicycle, having the same frame the same alignment, and provided with a chain and pedals for use at the rider's convenience. The motor, consisting of two cylinders is located behind the rear wheel, and the velocity is controlled by a

light rod running to the handle bar. The saddle is placed low enough to enable the rider to touch the ground with his feet, if necessary, thus avoiding the necessity of mounting from the rear. The tires are pneumatic "puncture proof," 5 inches in diameter, and entirely do away with the vibration of the frame, and can be driven over the roughest roads. There is an attachment to hold the machine up when not in use. Coasters upon the front fork provide a comfortable foot rest. The machine weighs but sixty-five pounds in toto, and is said to be capable of being driven through four inches of mud or sand at a rate of twenty miles per hour. It has made a straight way mile in 58 seconds on a street pavement.

The remarkable feature of this invention is the engine, which generates a maximum horse power with a minimum weight. Ordinary gasoline or kerosene oil flows by gravity from a tank to the engine, and is exploded by an electric spark, the consumption of fuel being about one-tenth gallon per horse power per hour. The cylinders are drawn steel tubes. "In some way wholly unexplained, the great heat which manifests itself as a by-product in other explosive engines is in the Pennington transformed into useful work upon the piston." This important result seems to be brought about by the method of ignition, in which, previous to the igniting spark, "a long thin ripening spark" is put through the charge. At any rate there results elimination of the excessive heat and the water jacket necessitated thereby and the securing of nearly double the efficiency of the ordinary motor of this class. The motor itself is described

as extremely simple, being of the "four stroke cycle" variety. "There is no visible discharge of vapor and no evident odor, except in case of an over admission of oil, which is immediately automatically corrected." The two horse power motor weighs but 17 pounds. One gallon of oil is said to be sufficient to drive the bicycle 100 miles over fairly smooth roads.

It is manufactured by the Kane-Pennington works of Racine, Wisconsin. Other forms are shown in the cuts.

Few people realize the wonderful revolution in locomotion that is going on in their midst. In 1880, there were thought to be about 300,000 wheels, all told, in use, at home and abroad, and

the yearly output was small. At that time, in this country, there was practically but one factory manufacturing bicycles—the Pope Manufacturing Company—which had been doing a moderate business since 1877, when it was organized; its total output up to 1880 being estimated at about 1,200 wheels. (*Scientific American.*) The same authority places the output of wheels in the United States alone, for the year 1895, at 500,000, and estimates that the production for the present year will reach 750,000 or more. At the recent Chicago Cycle Show, there were exhibited models of bicycles of over 120 different makes, and it is safe to say that there are over two hundred factories that manufacture wheels in the United States; some of these plants employ upwards of 1,000 workmen, and have a capacity of 20,000 machines a year, while others are much more modest concerns. Suppose, as a basis for a conservative estimate, we say the average number of employes is 150, making 30,000 employes in the bicycle factories alone. If to this number we add say one-third more engaged in the manufacture of bicycle material and bicycle sundries, it increases this number to a total of 40,000; but nearly every town in the United States has a mechanic whose time is chiefly or entirely given up to bicycle repairing, and in the cities there are many large shops for this purpose; if we say there is on an average one such mechanic to each 500 of urban population, we have 40,000 more; and if with this number we include those employed as bicycle agents, and otherwise, throughout the country, we shall probably be well within the limit in saying that there are 100,000 people in the United States who depend for their living upon the bicycle industry.

Already this popular machine is making itself felt in society, as a remarkable agent in moulding our civilization. It has done more in two years for dress reform among women than the advice of the medical profession and lecture platform have accomplished in fifty years. By its use, the business man and the workman alike, find it possible to reside at greater distances from their places of employment, so that the suburbs are rapidly building up at the expense of the hitherto overcrowded city. It is estimated on a conservative basis that one out of every score of the inhabitants of the United States is a wheelman; and physicians find an interesting question for discussion in the effect which so large an abandonment of the habit of walking, the development of muscles hitherto but little used, and the posture which wheelmen assume while riding are to have in the evolution of the race.

There is another result which this universal use of the bicycle is rapidly bringing about, and one which to the military man is of greater and more immediate consequence than any other; I speak of the improvement in our country roads and highways. For years we have been disgracefully behind every civilized nation of the first rank in the character of our roads. In the old European countries the highways were laid out and built centuries before the advent of the railroad, and both commercial and military necessity demanded that they should be well paved and made broad and spacious; good road material is abundant, labor is plentiful and cheap, and the roads being universally a matter of national concern are not allowed to deteriorate. In the United States the conditions have been very different; the early settlers were far more concerned in the clearing up and development of their lands than in the building of fine roads. Their numbers were small, and their resources limited, so that any practicable trail was all that was required for a highway. The dry season of the year was profited by in hauling their crops to the market and for the remainder of the year the farmer, living upon his own resources, was content to do what little traveling and trading he found necessary by going horseback. The necessity for good roads for military purposes has not been felt, with the consequence that our country roads remain largely in the same position and condition as when laid out by the original settlers, the roadway consisting of the natural soil and located with little or no attempt to make use of "the lay of the land" for the establishment of easy grades. But the bicycle is largely changing this condition. There has been a general awakening throughout the entire country to the necessity for better roads, due to the agitation of the wheelmen. Within the last few years the governors of nearly every State have made recommendations looking to the betterment of our highways, and much new and progressive legislation has been the result. This the observant traveler cannot but fail to see. It is to be observed chiefly in our large cities and country towns, where asphalt pavement is being substituted for the rough Belgian block paving, and where miles and miles of new macadamized roads are being built to the suburbs and extending out into the surrounding country. A great many of the smaller towns and municipalities have purchased rock crushers and road rollers, and the improvement of their streets is being rapidly effected. It is safe to predict that seven out of every ten male adults within the next decade will be riders of bicycles, and the effect of their united action will

be such that good roads will everywhere have to be built between the most important points in the country.

[TO BE CONTINUED.]

LIEUTENANT WILLIAM C. DAVIS,
5th Artillery.

PROFESSIONAL NOTES.

ORGANIZATION AND ADMINISTRATION.

Reorganization of the Russian Light Artillery in 1895.*

During the course of the year 1895, the Russian light artillery has undergone a thorough reorganization, not only in the grouping of the batteries, but also in the number of its units, and in its material.

A. Grouping of the batteries.—Hitherto the six light field batteries attached to each infantry division, have been placed directly, without intermediary, under the orders of the commander of the artillery brigade. But experience having shown that the artillery brigade commander could not preserve unity in the fire and movements of these six batteries of his command, it was agreed, that when two or three batteries came together temporarily at the same position, the command of them should devolve on the senior battery commander present. This middle course, however, was attended with many inconveniences which became evident at the maneuvers and in the firing drills, so it was finally abandoned for a more radical measure.

Since the commencement of 1895, the field artillery has been subdivided into groups of two or three batteries, having at their head a special permanent commander of the rank of lieutenant-colonel or colonel.

B. Creation of new batteries.—As a result of this reorganization, the light artillery brigade attached to each infantry division includes two groups of three batteries each, with eight pieces to a battery; to each *brigade de chasseurs* is attached a group of two batteries.

A recent order issued last September has directed the creation of 18 new light field batteries, to be distributed as follows:

Three batteries, constituting a group, are to reinforce the artillery brigade of the corps of the Guard.

Two batteries, constituting a group, are to reinforce the artillery brigades attached to each of the 2d, 4th, 6th, 10th and 18th divisions of infantry.

One battery to each of the five *brigades de chasseurs* of Russia in Europe, forming a group with the two batteries already attached to these brigades.

It is worthy of note that of the 18 new batteries, 16 are assigned to the military district adjacent to the German frontier. It looks as if this partial augmentation was but a preliminary step towards an increase throughout the whole light artillery.

C. Modifications in material.—While in most other countries, a greater rapidity of fire for light artillery is sought by a reduction of the caliber, by changes in the fermeture, and by the use of metallic cartridges, in Russia the same result is sought through modifications of the material already existing, that will not necessitate a change of the caliber.

The prime mover in this transformation is Lieutenant-General Engelhardt. The principal results, which he believes he has attained, are:

1st. The possibility of carrying on simultaneously the operations of loading and pointing, by removing the front sight and the seat of the rear sight, and

* Compare with Note, p. 517, vol. IV, *Journal U. S. Artillery.*

carrying them forward slightly toward the muzzle, at the same time moving them laterally, thus leaving the vicinity of the mechanism of the fermeture free, while the gun is being pointed.

2d. Almost entire suppression of the recoil by a spade attachment to the trail and by elastic buffers to connect with due adjustment the cheeks of the piece and the axle. After the second round, the recoil does not exceed six centimeters. A rapidity of fire of four and a half shots per minute is obtained. The increase of weight in the carriage is about 35 kilograms (77 lbs.). Five hundred carriages of this description have been ordered for the 8.7 cm. (3.43 in.) guns.

3d. Increase in the supply of ammunition, as a consequence of the increased rapidity of fire. By replacing the old style caisson drawn by six horses by a new model drawn by only two horses, it has been found possible, by thus tripling the number of caissons without increasing the number of teams, to transport 1680 rounds per battery instead of 1200 rounds.

4th. Increase in the killing power of the projectiles, obtained by the adoption of a new steel shrapnel, communicating to the bullets at the moment of bursting an additional velocity of about 100 meters (328 feet) per second.

5th. Adoption of smokeless powder, permitting an increase in the initial velocity of the projectile, without unduly increasing the pressure in the bore.

—*Jahrbücher für die deutsche Armee und Marine.*

[G.B.]

TACTICS, STRATEGY AND MILITARY HISTORY.

German Instructions on the Siege Works of Infantry and Field Engineers (Pioneers).

The *Revue* has already analyzed the instructions relative to siege works executed by the infantry and the pioneers, contained in the German regulations for field fortifications (*Feldbefestigungs-Vorschrift*, 1893). As these instructions are of special interest, and as they still remain in force, as is shown by the fact that they are reproduced nearly in full in the *Feldpioneer-Vorschrift für die Infanterie* (1894) and in the *Pioneer-Taschenbuch* of 1895, we will give a translation of them *in extenso*.

General observations.—The following instructions apply to siege works directed against fortified places by the infantry and the pioneers (fig. 1). Hence the principles here applicable may be derived by simplifying those pertaining to the more general case of fortified positions. The works of the infantry and the pioneers before a fortress begin as soon as investment is decided upon, and those first constructed are made with a view to protect the artillery. These works are limited essentially to the forms used in field works.

Siege works properly speaking consists of parallels* and approaches. Even under the most unfavorable conditions, they should permit the infantry and the pioneers to return the fire of the enemy, and to advance up to the assault of the defensive position *D*. The parallels and the approaches are called trenches.

The parallels are sheltered trenches for skirmishers, and they are carried forward as close as possible to the line occupied by the enemy. This close approach is the more necessary as each new parallel means a delay for the attack.

* Literally, infantry positions—*Infanteriestellungen.*

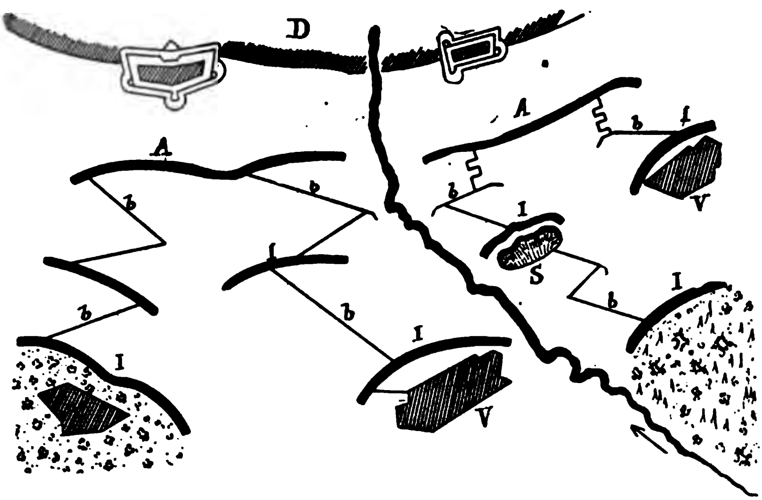


Fig. 1. Sketch of siege-works according to German Official Instructions.
V, villages. S, sand-pit

It is an advantage if the communications in rear are protected and if the various positions support one another.

The parallels (or infantry positions) are not necessarily continuous lines; but if they are not, the intervals are swept by the fire of adjacent parties or protected by throwing in reserves.

In general, the assault takes place from the last parallel, *A*, which is called the position of assault (*Sturmstellung*).

The approaches *bb* serve to join the parallels with each other, and with the covered places in rear. Their trace should keep them from being enfladed, and hence they are made zig-zag. Each element of the zig-zag is called a branch (*Schlag*). These branches are prolonged backwards, forming convenient corners for establishing ambulances, locating latrines, etc.

When the approaches have been carried close up to the work attacked, the zig-zag trace if properly defiladed would retard the advance too much, and hence the trench is pushed forward straight upon the work, and protection is obtained by means of parapets and blindages, (*communications à crémaillère, Deckwehrgräben*).

Profiles of the parallels.—The simplest form of the parallel is the sheltered trench for troops standing (fig. 2), which can be completed in the shortest nights, and under the most unfavorable circumstances. However, when it is practicable the strengthened trench (fig. 3) is begun at once and completed on the first night. On the following day, it is enlarged if necessary to profiles 4 and 5.

In certain cases, it may be necessary to adopt a larger profile even than this, as in the position for assault, for example. Steps or ramps must also be cut at this position to facilitate crossing the parapet.

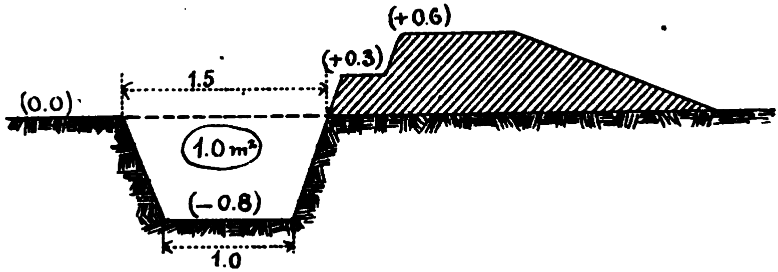


Fig. 2. Shelter-trench, for marksman standing

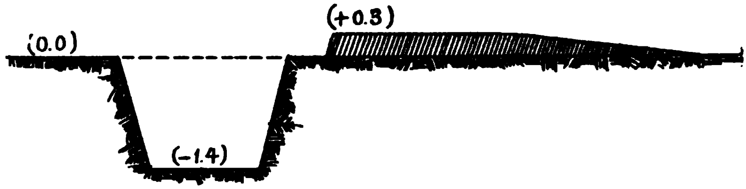


Fig. 3 Shelter-trench, for marksman standing.

The approaches are executed according to the profile given in figure 4, leaving out the steps and the rests for the men shooting. It is sufficient to start out with a width of one meter, which can later on be widened to about two meters.

The nature of the soil and the presence of water may oblige some deviation from the forms indicated. If the trench cannot be made sufficiently deep it is broadened so as to get earth enough to build up a parapet. On rocky ground, trenches are replaced by parapets of sand bags, etc.

Establishing the trenches.—In selecting the positions for the advanced posts, care should be taken to so place them that their trenches can be utilized later for parallels. Generally the trenches are not constructed at once in their full development, but progressively, beginning with detached portions, and joining these, or extending them.

The placing of the workmen to construct the trenches must be done secretly; hence this work must be done by surprise, and generally by night. In exceptional cases, where this is impracticable, recourse must be had to the slow process of the rolling sap, the manipulation of which belongs to the pioneers.

Before placing the workmen, the site of the trenches and the roads leading to them should be clearly indicated, the line for the trenches being marked by white streamers fixed in the ground. Moreover, officers who know the ground well and understand the work to be done, should be detailed with the troops.

In apportioning the work, the tactical units should be carefully taken into consideration. To each detachment is added the necessary pioneers (officers and men). Even in this case, however, the troops remain under the orders of their own officers, who are responsible for the execution of the work prescribed.

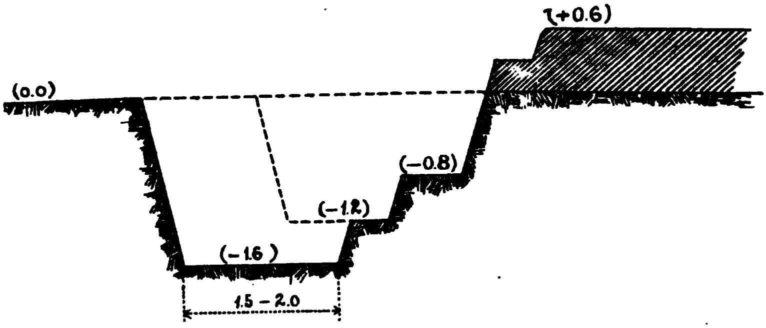


Fig. 4. Shelter-trench, strengthened.

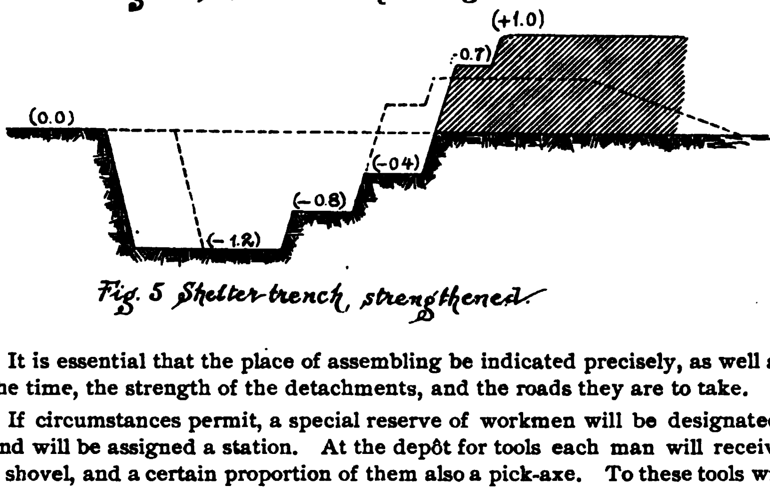


Fig. 5 Shelter-trench, strengthened.

It is essential that the place of assembling be indicated precisely, as well as the time, the strength of the detachments, and the roads they are to take.

If circumstances permit, a special reserve of workmen will be designated, and will be assigned a station. At the depôt for tools each man will receive a shovel, and a certain proportion of them also a pick-axe. To these tools will be added, according to circumstances, axes, saws, etc. If necessary, explanations can be given concerning the work to be done, and in order to facilitate this it would be a good thing to show the men a piece of trench work, as well as the proper positions of the workmen.

The march to the grounds and the work itself must be done without noise, especially should the tool be kept from striking against the rifle, and hence accurate directions should be given for carrying these. Orders must be given in a low tone of voice, and all speaking, smoking, and building of fires forbidden. Care should be exercised that portions of the columns do not go astray. Whenever during the march or while at work, a light is thrown from the place invested, the detachments lighted up will throw themselves on the ground and remain there motionless.

As a rule, the march to the working ground is not made directly from the place of assembly; but the detachments move first to relay points previously selected and located as near as possible to the place of work. It is often necessary to cross fields, since the roads are liable to be searched by lights or swept by fire. At the relay places the chiefs of detachment inform themselves, if necessary, as to the work they are to do, after which they march their detachments to the ground.

The workmen are extended along the line of the trench in single rank with two paces interval. This deployment can be done by the movement "as skirmishers," executed by company, by sections, or by file: all depends on the character of the night (whether dark or bright) and the lay of the ground.

The rifles are laid down and the work is begun. The reserve workmen, if there are any, remain provisionally in rear of their detachments.

The task done, the tools are left against the reverse slope of the trench, if it is to be widened at once.

The workmen usually march off by companies. If it is yet night, they take the shortest route, otherwise, they must take advantage of defiladed roads or use the trenches.

The ground should be clear before the arrival of the detail for widening.

Widening the trenches, and certain constructions.—The widening of the trenches is done whenever necessity demands it, usually immediately after they are completed. Those points are first widened where the guards and advanced posts are to be placed.

Certain special constructions are pushed forward as the work of widening goes on, such as establishing ammunition depots, shelters for advanced posts, telegraphic stations, ambulances, etc. If it is not intended to *débouch* from the parallels, accessory defences can be established in front of them.

It not unfrequently happens also that, in defending a place, trenches may have to be constructed to oppose an attack, and sometimes the defender must even make counter-approaches.

Removing and surmounting obstacles.—As artillery fire is not sufficient to destroy auxiliary defences in front of works or fortified positions, this task generally falls to the pioneers. Under these circumstances it is necessary first of all, to know the nature of the obstacles in order that the proper implements may be at hand.

The rule is, to have the clearing away of the obstacles over before the assault begins.

The pioneers endeavor to effect this by stealing up to the obstacles in small groups or one by one, noiselessly and under cover of darkness. Preferably the clearing away should be undertaken where the artillery have made gaps.

When the assault is ready the pioneers place themselves at the head of the assaulting detachments, to finish the removal of the obstacles or to clear away those that the enemy may have succeeded in placing in the meantime. If under exceptional circumstances the removal of the obstacles has to be deferred until the assualt, the pioneers general march with the line of skirmishers. The latter when they come near the obstacles crouch down and hold themselves in readiness to overwhelm the enemy by their fire, while the pioneers go ahead with their work.

Here and there points are found where the abatis is not very thick; here only a few branches need be cut away. Portable abatis and abatis made of branches can be dragged off by means of ropes when their fastenings have been removed.

To destroy wire entanglements the main wires are cut with shears, or with an axe using a piece of iron as an anvil. The stakes are either cut off or torn up.

Barricaded doors, weak walls, gratings, or other obstacles are forced in by a ram or broken up by other suitable means.

Inundations caused by checking a water course can only be drained by destroying the dams or opening a breach which can often be accomplished by artillery. Fougasses, or land torpedoes, can be rendered harmless by breaking the connections for firing, if they have not already been destroyed by the artillery fire.

High explosives are particularly adapted for destroying obstacles. The special instructions for pioneers give the necessary information on this point.

To surmount obstacles, the following means can be employed. Passage way can be made over ditches, palisades, crows-feet, etc., by covering them with bags, bundles of straw or hay, and boards. Water can be crossed by the aid of planks, fascines, and boughs; walls, gratings, and other high obstacles, by means of ladders, etc. Special instructions give the pioneers the necessary information for crossing obstacles.

When time and other circumstances permit, special exercises are arranged to give the troops destined for the assault, practice in destroying and surmounting obstacles.

An appendix of six and a half pages contains details for the pioneers in executing saps; they comprise the simple sap, the double saps, returns, *communications en crémaillère* executed by the rolling sap or as simple trenches. These methods differ so little from those of our own "school of the sap" that we will not dwell on them. We will limit ourselves to mentioning the formal direction for the officer in charge of the rolling sap, to take advantage of every favorable opportunity for concealing portions of the sap.

—*Revue du Génie Militaire*, December, 1895.

[G. B.]

Mortar Regiments of Field Artillery in Russia.

There are in Russia seven field mortar regiments which are, or will be, composed of four batteries each. According to the most recent informotion available, relating to these regiments, they are thus distributed over the empire: Dvinsk (Vilna), Biélaia Tserkov (Kiev), Varsovie (Varsovie), Novgorod (Saint Petersburg), Kolomna (Moscow), Kherson (Odessa), Karaklis (Caucasus).

No other official information is given as to the probable use to be made of these mortar batteries in time of war, but they appear to be destined to form a sort of general *army* artillery.

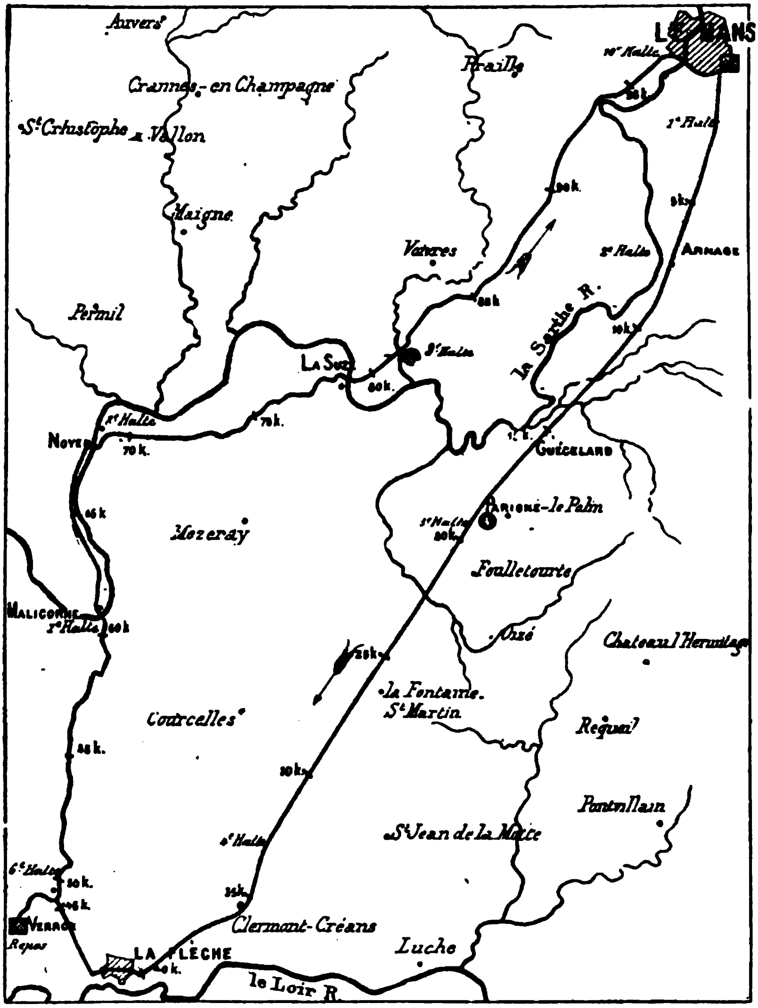
—*Revue Militaire de l'Etranger*, January, 1896.

DRILL REGULATIONS AND MANEUVERS.

France:—Account of a Practice March.

The 9th battery of the 26th regiment of artillery in April last marched 100 kilometers (62½ m.) in 24 hours. For this march the battery consisted of four pieces of 90 mm. and one wagon. The loading of the carriages and parks was as is required for active service. With the exception of the "cadres" the "personnel" of the battery was entirely made up of young soldiers who had reported during the previous month of November. All the battery horses marched except the five-year olds. Neither men nor horses had undergone any special training.

Details of the march.—The itinerary of the battery was as follows (see accompanying sketch map):



From Le Mans to La Fléche, 41 km. (25⅝ m.) by the national road* running from Nantes to Paris.

From La Fléche to Le Mans, 59 km. (36⅞ m.) by roads of less importance to the west of the preceding. The following are the varying elevations of the route :

Between the 2nd and 4th kilometers a rise of 40 m. (131.23 f.) followed between the 4th and 7th by a descent of about the same amount. Between the 18th and 30th kilometers a rise of 65 m. (213.25 f.) followed between the 32nd and 38th by a descent of 70 m (229.65 f.). Between the 50th and 58th kilometers, rises and descents amounting in the whole to changes in level of about 30 m (98.42 f.). Between the 68th and 83rd kilometers a rise of 30 m. (98.42 f.) followed between the 74th and 79th by about an equal descent.

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* *Routes nationales*, macadamized roads maintained by the government.—J. B. P.

The accompanying table shows graphically the arrangement of the marching time, the gaits and the rests.

The rests of more than half an hour were timed as follows:

9 hours	March of 3 hours from 4 to 7 p. m., distance 20 km. (12½ m.) Rest of one hour. March of 5 hours from 8 p. m. to 1 a. m., distance 27 km. (16⅞ m.)	47 km. (29⅜ m.)
	Rest of five hours.	
10 hours	March of 6 hours from 6 a.m., to 12 m., distance 35 km. (21⅞ m.) Rest of one hour. March of 3 hours from 1 to 4 p. m., distance 18 km. (11¼ m.)	53 km. (33⅛ m.)

Weather conditions: Continual rain with wind from 6 p.m. to 1 a.m., and from 6 to 10 a.m.; from this time until the end of the march showers.

Details of the movement.—The battery marched out at 3.50 p. m., cannoneers on the chests.

First halt.—At 2 km. (1¼ m.) from the starting point to inspect the loading of the carriages and the harnessing and packing of the horses. March of 5 km. (3⅛m.) at a walk, the cannoneers on foot at the head of the battery.

Second halt.—The cannoneers take their places on the chests. The battery does 3 km. (1⅞ m.) at a 200 m. trot, 3 km. at a 100 m. walk, 3 km. at a 200 m. trot, and 3 km. at a 100 m. walk.

Third halt.—This halt lasts one hour. The horses are fed oats. The men take a cold meal and some hot wine. The night has fallen and is very dark, The road is soaked and heavy. The battery starts at a walk, the drivers on the chests, the cannoneers at the horses' heads.

Fourth halt.—This halt is made at the end of 14 km. (8¾ m.) and lasts a half hour. The cannoneers mount the chests, the drivers march at their horses' heads, the driver of the swing team on the off side; each lead driver is required to lock the brake of the piece in front of him when going down hill.

Fifth halt.—This halt begins at 1 a.m. and lasts five hours. The horses are unsaddled and unharnessed, then groomed with the help of the cannoneers. In three-quarters of an hour they are watered, then sheltered in a cow stable and fed oats. The men have a hot meal and lie down in a hay loft. They sleep three hours. At 5 a. m., reveille. The horses are watered and fed. The men eat a hot meal and take a cold one with them. The start takes place at 6 a. m. The cannoneers march at the head of the battery.

Sixth halt.—Half an hour after the start to inspect the harnessing and packing of the teams. March of 10 km. (6¼ m.) everybody on foot.

Seventh halt.—The cannoneers take their places on the chests. The battery does 4 km. (2½ m.) at a 200 m. trot, 3 km. (1⅞ m.) at a 100 m. walk and 3 km. at a 200 m. trot.

Eighth halt.—The cannoneers march for 12 km. (7½ m.) at the head of the battery.

Ninth halt.—This halt lasts one hour. The horses are watered and fed. The men take a cold meal and some hot wine. The battery marches 15 km. (9⅜ m.) at a walk, the cannoneers on the chests.

Tenth halt.—This halt occurs before entering the town. The battery marches 3 km. (1⅞ m.), the cannoneers at its head, and reaches the barracks at 4 p. m.

Not a man nor a horse remained behind or was indisposed either during or after the march. The next day a careful examination of the horses was made in the presence of the veterinary surgeon. Not a horse was found to

have been hurt nor was any trace of abnormal fatigue to be observed. After one day's rest, all the horses, without exception, resumed their regimental service.

—*Revue d'Artillerie*, February, 1896.

[Translated by Colonel John Biddle Porter, N. G. Pennsylvania.]

French Field Artillery.

From "*Leçon d'Artillerie*", a book by E. Girardon, the contents of which have already been referred to in the "*Militär-Literatur-Zeitung*," we take the following information which may be of interest to a more extended circle.

The short 120 mm. gun, model 1890, has been introduced in the field artillery; it will fire shrapnel against covered targets, but a shell filled with melenite will be used against such as possess a strong resisting power. The shrapnel is base loaded, weighs 20.55 kg. (44.8 pounds), contains 630 bullets weighing 12 grams (185 grains) each, and has a bursting charge of 320 grams (0.7 pounds) of powder. The small weight of the shrapnel bullets is noteworthy, for those contained in the shell (obus à mitraille) of the 80 and and 90 mm. mitraille weigh 15 grams (231 grains). The angle of the cone of explosion with the practice charge is given as 14°; probably this is a printer's error, and should read 28°.*

The melinite shell has a bursting charge weighing 6 kg. (13 pounds), and is provided with a simple percussion fuse. The French expect little effect from melenite shell exploded by the time fuse, but expect the more from those exploded by percussion; especially do they consider those of the 120 mm. guns as well adapted against field works as a single hit is sufficient to make a breach. It is claimed that the melenite shell will act against living objects not only by means of the pieces produced by the burst, but also by the resulting air pressure, which it is claimed, will be of sufficient force to throw down living beings with such violence as to produce serious internal injuries; even fixed targets that possess only small resisting powers, such as thin walls, palisades, etc., are expected to be thrown down by this pressure.

If a melenite shell should burst in a closed room all persons in it would be killed by the resulting air pressure. This seems quite probable, for the melenite shell of the 90 mm. gun has a bursting charge weighing 1.4 kg. (three pounds), a charge about eight times as large as that of the German shell C/88. The melenite shell for the 90 mm. gun is not expected to produce great effects against earth targets. The firing regulations for the French field artillery have been undergoing a continuous change for the last few years. Even the latest "*Manuel de tir de campagne*" of March 15th, 1894, is only an outline. The whole "*manuel*" is not at our disposal, but the study of Girardon's book gives a good idea of the fundamental principles there set forth, and that is the all important part.

The greatest change consists in the elemination of the method of correcting elevations by the elevating crank, the description of which takes up considerable space in all previous regulations. The older breech sights had to be taken from the gun whenever a change of elevation was to be made. As this required much time and had to be done very carefully, it was generally the

* At another place "les angles des cônes" of the 90 mm. "obus à mitraille," are given as 8° at 150 m., 8½° at 2,500 m., 9° at 3,000 m. and 10° at 4,500 m. Evidently these figures suit well for one-half of "l'angle du cône," as all other sources give this angle about twice as large. Such angles for shrapnel of short guns are always greater than those of guns having flatter trajectories.

custom to aim but once with the rear sight and after that changes for elevation were made by means of the elevating screw. This was found to be an endless source of errors and misunderstandings. Recently a sight with an arrangement of cogs has been introduced, and by means of this a rapid and accurate adjustment is possible. The new "*Manuel de tir*" therefore only prescribes commands giving the distances, as is also done in Germany. The quadrant and fuze divisions into degrees and seconds, respectively, are retained and hence the chiefs of platoons are still compelled to read the required data in range tables or on the sights.

For stationary objects more distant than 1,500 m. (1,625 yards) the range is generally found by means of the percussion fuse, after which the time fuse is used. For less distances the percussion fuse alone is used, as for short distances the advantage of time over percussion fuses is but little, whereas the rapidity of fire can be greatly increased by not having to cut the fuses. Probably this latter consideration is the decisive one, as in fact the cutting of French fuses is a very delicate matter.

Firing with percussion fuses, the range is sought to be found as rapidly as possible by getting a fork of 200 or 400 metres and gradually reducing this to 50 m. To make the results more accurate a repetition of the shots for the wider fork is permissible. Firing is then continued at a range taken to the middle of the 50 m. fork and if, out of the next four shots, two are found short, and two over, no further correction is made; otherwise one of 25 m. is made.

In firing with time fuses, a fork is established, using percussion fuses, which is narrowed down to 100 m.; under certain circumstances a fork of 200 m. will suffice. The range is then taken to the middle of the fork and the battery then uses the time fuse. However, as a rule, one platoon (usually one of the flank platoons) keeps on using the percussion fuse and by means of this platoon the battery commander endeavors to obtain a more accurate range. At first he will ascertain if his final fork is correct (*vérification de la hausse*). For this purpose a range is taken to the middle of the fork and one shot is fired. If this shot is short the range is incerased, if over it is diminished 50 m., i. e., the range is taken to the extreme end of the fork. If now a shot is observed to go over in the former case, or fall short in the latter, it will prove that the fork is correct. But if the shot strikes the other way, i. e., short instead of over in the former (*over instead of short in the latter*), so that for this distance two contradictory observations are recorded, it will be a question whether this latter distance can be used for the range or whether the fork has been wrongly established. A further increase or decrease of the range by 50 m. will clear the matter up. An example will make plain the method of procedure. Consider a fork between the ranges of 2,000 m. and 2,100 m.; the following six cases are then possible:

1	2	3	4	5	6
2050— 2100+	2050+ 2000—	2050— 2100— 2150+	2050+ 2000+ 1950—	2050— 2100— 2150—	2050+ 2000+ 1950+
Fork correct.		Ranges 2100 and 2000 m. respectively.		A wrongly established fork.	

The remarks under 3 and 4 simply mean that the probable error in taking the ranges to be 2100 and 2000 m. respectively, will not be greater than ± 25 m. Therefore for cases 1 and 2 the fuse may be cut for a 2050 m. range, in case 3 for a 2100 m. range and in case 4 for a 2000 m. range, with prospects of obtaining good results, whereas for cases 5 and 6 the establishment of a new fork will be necessary. In special cases, for example against artillery, it is permissable to get a more accurate range, i. e., correct within 25 m.

The trial of the distance at which the time fuse is first used is considered to be a suitable proceeding; also little can be said against the method and manner in which this is done. On the other hand it is doubtful if the time should be taken to get a more accurate range, and least of all would this be justifiable in an artillery duel. Everything will not depend so much on obtaining the greatest possible effect as on obtaining a sufficient but *timely* one.

While the battery commander controls this part of the firing with one flank platoon (*section-guide*), the other two will have passed to the use of time fuses, each one regulating its own height of burst. They will make use of the last range ordered by the battery commander, and will, in case of necessity, make simultaneous correction with the breech sight and in cutting the fuse. The height of burst is correct when the center of burst is $\frac{4}{1000}$ of the range, i. e., for 1000 m., 4 m., for 2000 m., 8 m., etc.*

If the correct range has been found we will obtain at these heights of burst a dispersion of the points of bursting (in range) at

1000 m. of 95 m.
2000 m. of 60 m.
3000 m. of 46 m.
4000 m. of 40 m.

This normal height of burst (*hauteur type*) has for all ranges the same *apparent* height, and therefore, after some practice, the eye can readily determine the correct height.

Points of burst which are higher than this "*hauteur type*" are called *high;* if more than twice as high they are called *very high*. Points of burst which fall below this "*hauteur type*" are called *low*, and if, as when firing at a high target, they fall below the target they are called *very low*. The chiefs of platoons should correct the fuse cutting after every two observed shots, and this correction should be made to the extent of

0.4″ after having observed 2 *very* high (or low) bursts.†
0.2″ after having observed 2 high (or low) bursts.
0.1″ after having observed 1 high (or low) and 1 normal burst.

As soon as the battery commander considers that he has an accurate range, he will cause his platoon to use the time-fuse, then give the necessary commands for the entire battery to take the range as finally decided upon, direct special pieces to fire at special parts of the target, and will cause several rounds (*une rafale*) to be delivered at rapid fire.

By carrying out these regulations the greatest possible effect will, without doubt, be obtained; it will only be a question as to how, in serious affairs, the mechanism will work. The practical regulation of fuse cutting calls for educated officers, especially as they can only make use of a range given by the platoon still using percussion fuses. In cutting the fuse they cannot make

* This measure corresponds to a change in rear sight of $\frac{1}{16}$° in the German field artillery.

† *Very low* points of burst can only be obtained when firing at targets higher than the gun; on a level plain it will strike the ground.

use of the range alone, ordered by the captain, but must take into account the corrections demanded by their own observations. It has already been observed that this cannot be done without the use of a range table, and it may be asserted to be almost impossible without the use of written notes.*

It is expecting rather too much from an officer to require him intelligently to make out these corrections (which alone demand close attention) at the same time that he is observing his shots and supervising the service of the piece, his platoon being under fire all the while.

In regard to corrections for deviation it is prescribed that consideration shall be given at the start to the deviating component of the wind and to the inclination of the wheels of the carriage. The former is the duty of the battery commander and the latter that of the chief of platoon. The manual rightly cautions against "weak" corrections, which lead to nothing, and recommends, when the deviations of the first shots are great, deviation corrections of 10 mm. (about 12 divisions of the deviating scale on the German guns); for all other deviations observed in the beginning it recommends a correction of 5 mm.

In firing at *moving* targets, the first thing to be determined is the direction of the movement, i.e., whether it is to the front or to the rear. Either percussion or time fuse may be used. After the direction of the movement has been determined, the rules for firing with percussion fuses are the same as those prescribed by the German regulations, with the difference that the fork is always established by one platoon only, the other platoons conforming to the results thus obtained. If a shot has been observed to fall over (or short), and it is necessary immediately afterwards to make use of rapid fire, it is permissible to turn backward (or forward) the crank handle of the elevating screw a quarter, a half or a whole turn, depending on the rapidity with which the gun is aimed. Such a regulation formerly existed in the German service, but was repealed ten or twelve years ago as unsuitable to the purpose.

If the direction of the movement cannot be made out, a circumstance which may readily happen when an oblique movement is being made at a great distance, then a fork of 100 m. is established, which fork is later reduced to 50 m.; if the shots still strike short or over, a corresponding change of 50 m. is made in the range (*tir de surveillance*). If an effect is observed the elevation is retained. If on the other hand, after two corrections of 50 m. each have been made according to the above method, further deviations towards the same direction are observed, the direction of the movement may be determined, and then the rules for advancing or retreating targets are followed.

Against targets moving towards a flank, deviation corrections must be made (compare with Par. 127, German firing regulations). When, after the establishment of the fork the firing with time fuses begins, one of the flank platoons retains the percussion fuse in order to be more certain of the movement of target; the other platoons fire a volley as the target approaches one end of the fork.

In certain cases,—for example, when the ground at the target is marshy or covered with snow, or when hostile artillery occupies a height to which both front and rear approaches are very steep, or when the projectiles at great distances penetrate the ground deeply, in short, whenever the percussion fuse cannot be observed,—*the range is found directly by means of the time fuse* (*tir d'emblée*). For this purpose, it is endeavored to get a point of

* The chiefs of platoon may also have calculating rulers (*r'glettes de correspondance*) which will make it easier for them to carry out the corrections.

burst lower than the normal, and then, firing by platoons, a fork is established by making simultaneous corrections for elevation and fuse setting. At the proper range,—to what limits the fork should be narrowed down is not stated—the correct height of burst is obtained by cutting down the time fuse.

When *observations* are made with *difficulty*, or when the establishment of a fork of 100 m. does not succeed, or when it is believed to be of importance to use the time fuse early in the fight, it will suffice to take a space of more or less depth and bring it under fire by making simultaneous corrections for elevation and fuse cutting (*tir progressif*). The firing with time fuses is begun by taking for the range the distance to the near end of the fork, or if no fork has been established, the distance to the furthest "short shot" is taken. For the succeeding shots the ranges are increased 100 or 200 m., but the corrections should be so made as to finally still fall short of the target. If a fork has been established, firing at the long fork range should be avoided.*

The depth of the space to be put under fire may be reduced in accordance with the result of the observation. In order that the battery commander may carry out these observations undisturbed, the firing is conducted by the chiefs of platoon, a duty which at other times belongs to the battery commander. It is recommended that one platoon fire with its fuses so cut as to give low points of burst, even if some of the effect is thereby lost, because in this way more shots may be observed.

Canister is used in cases of surprises and sudden attacks at close quarters; for example, against cavalry which is closer than 600 m. A superficial aim will suffice. Canister fire must be delivered with the greatest coolness, and is carried out by platoon volleys at the commands of the battery commander or of the chiefs of platoon.

In *firing by battalion* (or groups of batteries), the commanding officer's duty is to see that the batteries under him perform the work prescribed by the regimental commander. He picks out the position the batteries are to occupy, sees that the ranges are obtained before the batteries go into action, and obtains from the neighboring troops already engaged all such information as may be of value to him. He divides the terrain to be placed under fire into several targets, dividing them among the different batteries; he also orders changes of targets, directs and supervises the replacing of ammunition and looks out for the protection of the batteries; he pays special attention to the development of the battle so as not to confound hostile with friendly troops. Firing over friendly troops on level ground is permissible only when the same are at least 500 m. in front of his guns and not less than 500 m. in front of the target fired at.

The battalion commander may take a position within a battery or else on one of the flanks of the battalion in order to observe the firing of his batteries. The battery commanders are responsible for the determination of their own ranges; at the same time the battalion commander may order a battery to take a different range if he doubts the accuracy of the range found, and in case of necessity must assume charge of finding the range.

Generally the battalion commander designates a battery, the one best fitted for the work, whose special object is to get the range (*batterie-guide*).

Speaking of *firing by battalion* (*tir de groupe*) the manual means such firing as is conducted by a whole battalion firing at one and the same target. The

* "En principe on fait autant de bonds, que l'encadrement renferme des fourchettes *moins une*, afin d'éviter sur la limite longue."

mode of action varies, according as to whether the target is so broad that it can be divided among the three batteries, or else so narrow that it cannot be so divided in getting the range. In the first case each battery gets its own range; however, the battalion commander informs all batteries of the range found by the *batterie-guide.* If the difference between the latter and that found by the battery, after considering any difference of position, is greater than 100 m., the battery commanders will be controlled by their own ranging; in no case will they accept the range given them without testing it.

When the targets are narrow, it is difficult for several batteries to get the range at the same time, because the projectiles from the different batteries are apt to cause confusion. The battalion commander therefore designates the "*batterie-guide*" to obtain an accurate range, while the other batteries immediately open fire, using the time fuse, and making use of a range estimated by the *batterie-guide.* But they must be careful to cut their fuses so as to get a higher than a normal point of burst, so as to eliminate all probability of getting a burst on impact, which would interfere with the work of the *batterie-guide.* As soon as this battery obtains the range the other batteries make use of it.

In getting the range, the rapidity of fire must not be greater than will enable one shot to be observed before a succeeding one is fired. Considering the time of flight there will result, at 2000 m., a rapidity of fire of three shots per minute, and at 4000 m., of two shots per minute. After the range is found, the rapidity of fire will conform to orders from the battalion commander, or to the conditions of the battle. A well trained battery, possessing modern material and firing by platoons, can deliver twelve shots per minute. Orders should be given in advance for a certain number of shots to be fired at rapid firing as soon as the range is found, in order to heighten the normal effect produced by sudden heavy losses.

We have often expressed our opinion in regard to the value of such a rapid fire; it is permissible only when the range has been accurately determined, so that a further observation of the shots is unnecessary; but in that case a few shots (two volleys) will answer the purpose. However, it requires much time to get an accurate range, and it is more than probable that an opponent, who seeks merely a sufficient but quickly obtained effect, which he improves by making use of the observation of his shots, fired in a calm and deliberate manner, will cause us to retire before use can be made of rapid firing. Undoubtedly a result of this method will be the use of rapid fire before an accurate range has been found and consequently a waste of ammunition will follow. Above all, there will be created a restlessness among the cannoneers which will have a general bad effect and which will make it specially difficult to maintain a proper fire discipline,—a state of affairs almost certain to bring about poor aiming.

Girardon is undoubtedly one of Langlois' adherents; this is thought on account of the views he entertains in regard to the gun of the future, which, he thinks, will be a light, quick firing, 75 mm. gun and which will fire at least six shots per minute and have no recoil. But he cares nothing for the "tir échelonné," the Langlois' firing method, which of necessity applies to such a gun; he even thinks that too much ammunition is used by the "tir progressif." On the other hand it may be remarked that nothing is said by simply designating a piece as a "light rapid firing gun of about 75 mm. (2.96-inch)caliber" for some guns of this caliber fire projectiles weighing 4.3 kg. (9½ pounds),

while others use projectiles weighing 7 kg. (15 pounds). But the weight of the projectile, and not the caliber, is the decisive factor in the effect produced by a gun, which, be it remembered, is something very different from a small arm rifle.

—*Militär Wochenblatt*, No. 90, October 12th, 1895.

[Translated by Lieut. H. C. Schumm, 2d Artillery.]

The Grand Maneuvers of 1896—Germany.

This year there will again be grand (*Kaiser*) maneuvers, and these are to take place in a historic region, namely, between Bautzen and Görlitz, and will probably demand high requirements from those participating in them. On the one side will be the V and VI Corps under the command of Count Waldersee, on the other the XII (Saxon) Corps, composed of three divisions, to which will be joined the 8th division of the IV Corps, all under the command of Prince George of Saxony. In each army will be organized army staffs (a measure not carried out in 1895 for special reasons) who will retain charge of the conduct of affairs, so that changes in the command will not take place. It is reported that this is the Emperor's special wish. * * *

—*Allgemeine Militär-Zeitung*, January 13, 1896.

ARTILLERY MATERIAL.

a. Guns and Carriages.

The new French Field Howitzer.

The material of the French field artillery has been increased by the addition of a new gun, for which a special *drill regulations* was issued by the Minister of War on the 28th of May last. The new gun, which was taken along in special heavy batteries in the maneuvers of last fall in the Monts Faucilles and attracted considerable attention there, is described in great detail in *L'Avenir Militaire* of the 10th of December, 1895, and that description is the basis of the following discussion on this new 120 mm. (4.7 inch) gun, which, by the way, has just been taken up in the new French drill regulations for field artillery.

The effect of a gun depends (among other things) on the weight of its projectile; for, if we leave out of consideration the velocity imparted to the projectile, its effect against living objects is directly dependent on the number of balls, in case of shrapnel, or on the number of fragments, in case of shell, which in their turn have a definite relation to the weight of the projectile.

The weight of the new 120 mm. shell is 20.35 kg. (about 47 pounds), and is therefore about two and a half times as heavy as the ordinary shell of field guns. From this we might draw the conclusion that the new field gun surpasses the old one in the same ratio.

The two forms of projectile of the new gun, which has received the official designation of *canon de 120 court*, short 120 mm. gun, are a shrapnel M. 1891 (*obus à balles*) and a torpedo shell (*obus allongé*).

The shrapnel, M. 1891, has a bursting charge of 280 grams (4320 grains or 0.6 of a pound) of what is officially designated as F^3 powder. The shrapnel contains 630 balls of hard lead, each of which weighs 12 grams (185 grains); this gives 7.56 kg. (16⅔ lbs.) effective weight, or 37% of the total weight of the projectile. This shrapnel acts on obstacles (inanimate objects) by its energy, and on troops by its fragments (including balls).

The torpedo shell, the designation of which, *obus allongé*, points to a considerable length—in this case four calibers—is charged with melinite; it is distinguished externally from the shrapnel not only by its length, but also by its color, the torpedo shell being yellow, the shrapnel red. (These colors correspond to those adopted by us).

The charge of the gun is put in a linen cartridge-bag, and consists of *BC* powder, the so-called smokeless powder, which has the appearance of small rolls or bundles of thin leaflets. The different weights of these thin sheets or leaflets used in the charge correspond to three modes of loading, called the normal, medium and small charges of the short 120 mm. gun. The normal charge is 550 grams (8486.5 grains or 1.2 lbs.), the medium 330 grams (5092 grains or nearly ¾ of a pound), and the small 220 grams (3395 grains or a little less than ½ of a pound). These variations in the charge are necessary in order to obtain the angle of fall suitable for the best effect of the projectile in every situation and under the various conditions liable to arise in war.

The tube of the new gun is made of steel like the old field gun; its weight is 690 kg. (1518 pounds), that of its carriage is 785 kg. (1749 pounds), which gives a total weight for the gun mounted without its limber of 1475 kg. (3245 pounds). The limber alone weighs 890 kg. (1958 pounds), so that the entire weight of the gun mounted as a wheeled vehicle is 2365 kg. (5203 pounds), which very materially exceeds the limit of weight fixed by artillerists for a practicable field piece.

The new gun has a peculiar appearance on account of a mantle holding the trunnions, surrounding the piece at its middle and connected with it by means of a hydraulic brake, and resting, together with the trunnions, on the carriage.

The hydraulic brake consists of a steel cylinder filled with mineral oil connected with the piece by a disk on the breech-block ring and by the air receiver or *récoupérateur*, which is screwed into the mantle (or jacket).

When a shot is fired the recoil takes place in the mantle, and the cylinder is carried along. The brake is so arranged inside that this movement to the rear produces pressure on the liquid and causes it to flow out by opening a valve, whereby the air in the air holder (*récoupérateur*) is compressed, thus limiting the recoil of the piece.

After recoil the compressed air exerts a pressure on the liquid and causes the latter to flow into the cylinder again, carrying the cylinder forward and thereby bringing the piece into position again. The maximum distance through which the piece can recoil in the mantle is 475 mm. (18.7 inches).

The new gun, which is mounted as a *field howitzer*, has also a peculiar carriage, composed of a lower part—the large carriage—and an upper part—the small carriage. The upper carriage is attached to the lower in such a way that it can be revolved sideways, and on the march can be fastened down to the lower carriage, to be raised only when required for firing.

The short 120 mm. field howitzer is therefore in every respect a new gun. Being much more complicated than the ordinary field gun it will also require a more careful training of its cannoneers.

"It is evident," says *L'Avenir* in conclusion, "that at present the field artillery is becoming more and more complicated. At the very moment when this new gun actually effects an increase of caliber and of weight of material, we are at work with another gun, still in the experimental stage, which is

designed to effect a diminution in caliber and a reduction in weight of material. [The gun here referred to is the new field gun of 75 mm. (a little less than three inches) with a projectile weighing 6.5 kg. (14⅓ pounds), which is to have somewhat the character of a rapid-fire gun.—The author.] It appears, therefore, that we are on the threshold of a separation in field artillery of the two opposite kinds of material. How the union of these opposite characteristics is to be effected hereafter in a single piece will be the next problem to be solved, a problem which is sure to arise very soon, because in the field artillery, just as in the infantry and cavalry, victory will fall to the simplest material, which in a type of gun, intermediate in mobility and power, combines the qualities of "a maid of all work" (*la bonne à tout faire*), and can fire either with great rapidity or with great striking energy according to circumstances.

—*Militär-Wochenblatt*. No. 114, December 28, 1895.

[Translated by Lieutenant J. P. Wisser.]

b. Armor and Projectiles.*

An Experimental Test of the Armored Side of U. S. S. Iowa.†

Ever since the rehabilitation of our Navy was begun, a dozen years ago, every effort has been made to secure a high grade of armor for our vessels. The requirements for this material have been made more and more severe, as the armor makers have demonstrated their ability to fulfill them, until now, in the reforged, Harveyed, nickel-steel plate, we are unquestionably producing the finest armor in the world. During all this time every lot of armor has been subjected not only to the usual physical and chemical tests as to quality, but a representative plate of each lot has been subjected to the crucial test of the gun. The size of the projectile and charge of powder have varied in accordance with the thickness and prescribed quality of the plate, and have both been steadily increased as the improvement in quality took place.

Not only has the ballistic test acted as a continual spur to the armor makers to improve the resisting power of the armor, but it has given us definite information as to all the armor actually on our ships. The effect of a certain gun on the armor of any of our vessels is thus no longer a matter of opinion, but has become a matter of definite knowledge. We know just what effect will be produced on any armor plate by any particular projectile fired from any given distance with the usual service or any other charge. And this knowledge is of the utmost importance, for it enables the commanding officer in time of battle to gauge accurately the danger to which his ship is at any time exposed; he knows to what guns of the enemy and at what range his side is invulnerable, as well as what other guns and distances may mean certain penetration.

But all this presupposes that the armor is held up to its work. Of what avail would it be that the armor was the finest quality if a shot striking it should drive it bodily into the side of the ship or so strain and injure the latter as to permit large quantities of water to enter? Or that a fracture in the armor should be accompanied by a similar injury to the side of the ship?

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* Our attention has been called by Captain Heath, commanding the Proving Ground at Sandy Hook, to an error in our last issue. On page 105, line 8, the weight of the Holtzer projectile should have been given as "575 lbs.,—the firing was made from a 10-inch rifle."

† Abstract of a paper read by Albert W. Stahl, Naval Constructor, U. S. N., at the convention of the Society of Naval Architects and Marine Engineers, held in New York, November 7 and 8, 1895.

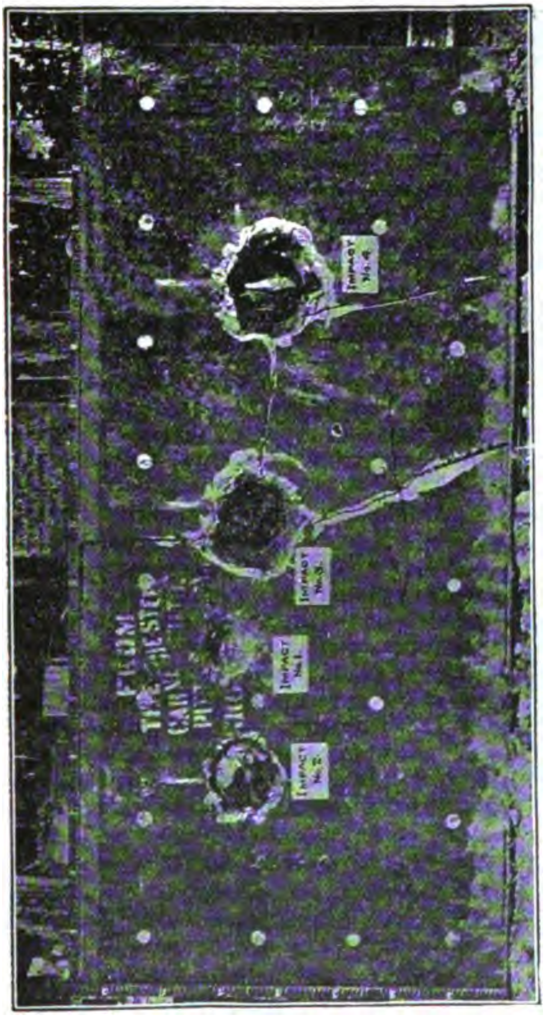


Figure 1.—Front View of Target After Test.

Realizing the importance of certainty in this matter, the Navy Department has recently made a crucial test of the armored side of one of our representative battle ships, the *Iowa*, with the most gratifying results. The framing fully demonstrated its ability to hold the armor up to its work, sustaining only most trifling injury as the successive shots were gradually increased in penetrating power, until the armor was actually completely pierced, and even then sustaining local damage only.

The *Iowa* is one of our recent battle ships, still under construction. She is 360 feet long, 72 feet 2½ inches beam and 24 feet draft, having a total normal displacement of 11,296 tons. Her main battery consists of four 12-inch and eight 8-inch breech-loading rifles in turrets. Her principal vital points are well protected by heavy armor. The special point of interest to us at the

Figure 2.—Injury to Framing by Fourth Shot.

moment is her side at and about the water line. For a considerable portion of her length this side is protected by a belt of armor extending from 3 feet above to 4½ feet below the water line. The upper portion of this armor is 14 inches thick down to a point one foot below the water line, below which it decreases in thickness to 7 inches at bottom. The armor is imbedded in the ship's side so that its outer surface is flush with the outside plating of the vessel, while its inner surface is bolted against an elaborate system of framing forming a portion of the hull; and it was the efficiency of this framing that it was the prime object of the recent test to definitely either establish or disprove.

The target.—For the purpose of this test a target was constructed of the length of one armor plate, consisting of all the framing which exists in the actual ship in rear of such plate, to which was attached in the usual manner the actual armor plate seldcted for the ballistic test of a group of this armor.

The framing extended the height of the armor plate, and in an inboard direction included the first longitudinal bulkhead within the armor. The total

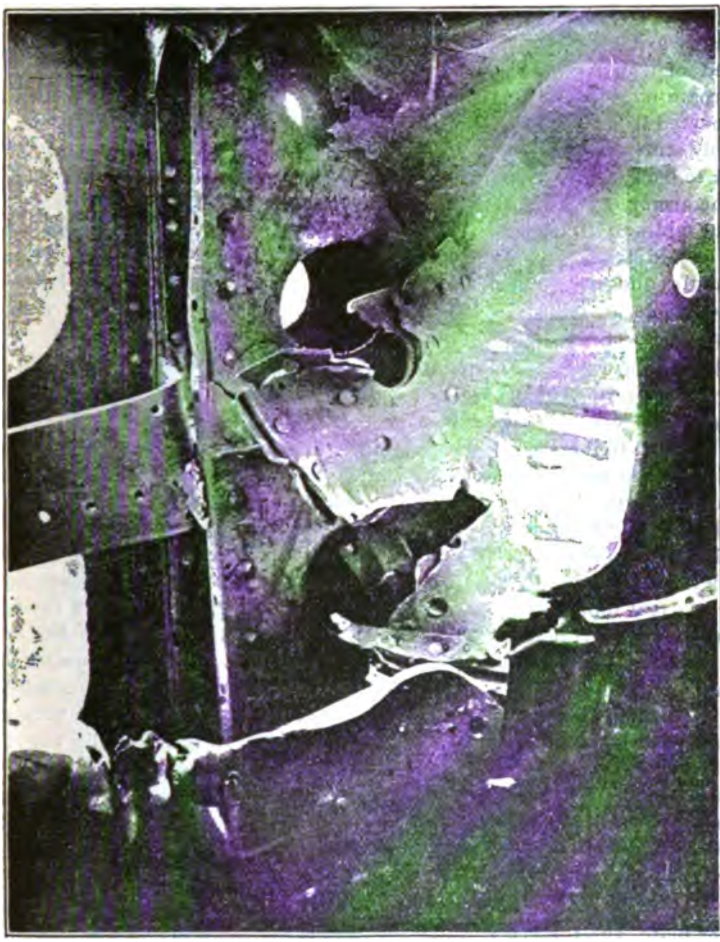


Figure 3.—Injury to Framing by Fourth Shot.

structure was thus 16 feet long over all, (6½ feet wide and 7½ feet high). While such an isolated portion of the ship's side cannot, of course, offer absolutely the same resistance as the corresponding part of the ship itself, thoroughly connected as the latter is with the rest of the hull, yet it was deemed to be a sufficiently fair test to warrant us in accepting the results of the same as representing, with a considerable degree of accuracy, what would happen in the ship under similiar circumstances.

Figures 6, 7 and 8 show the target used in the test. Figure 6 is a transverse section; to the left is the armor, 14 inches thick in its parallel upper portion, and tapering down to 7 inches at the bottom. Between the armor and the framing proper is the wood backing, 5 inches thick in its upper portion, and tapering to suit the shape of the armor in the lower portion.

Immediately within the wood backing are two steel backing plates, each ½ inch thick; these plates in the *Iowa* are really ⅝ inch thick, but the lesser

thickness was used in the target both as a matter of convenience and to bring it into accord with the ½ inch thickness adopted in the design of the two recently authorized battle ships, Nos. 5 and 6. The rest of the framing consisted of transverse vertical bulkheads ½ inch thick and 2 feet apart, the alternate ones being extended to the rear with a thickness of ⅜ inch and connected to a main longitudinal bulkhead of the ship, while the others were simply stiffened at the rear with a flange consisting of two angle irons riveted back to back. The longitudinal members of this cellular framing consisted of the armored deck above, an ordinary deck below, and a horizontal plate at about mid-height, together with 3 vertical stiffening plates at top, at bottom, and at mid-height respectively. The various portions were thoroughly united by angles and butt straps. Figure 7 shows also the number and location of armor bolts, of which the upper ones were 2.8 inches diameter, while the lower ones were 2.4 inches in diameter.

This target was secured to a heavy supporting structure so arranged as to support the target at top and bottom only, representing the support due to the decks of the vessel. Figure 5 shows this supporting structure. It consisted of 8 vertical timbers of oak, butting at the bottom against horizontal timbers, and near the top against inclined braces, all these timbers being about 15 inches square. The incline braces were secured to the verticals by heavy angle irons, and by bolts to the horizontals below them. Behind the junction of the horizontal and inclined timbers were placed a set of nearly horizontal timbers 16 x 9 inches, which in turn rested against piles 20 inches square driven 5 feet into the ground. The latter are not clearly visible in the figure, being partly covered by sand. Running to the front from the feet of the verticals were other horizontal timbers, 15 inches square, the front ends of which were bolted down to doubled cross timbers, 12 inches square, imbedded in the ground. This extremely strong structure was then filled in with sand, so as to render it as rigid and unyielding as possible: and finally the target was secured in the front angle of the same by about 100 1½ inch bolts, being separated from the main structure by cross timbers at top and bottom, the object of the latter being to confine the resistance to the two deck levels, as above explained.

The shots.—Four shots were fired at this target—two 10-inch, one 12-inch, and one 13-inch—the first two forming the regular acceptance test of the armor plate, and the last two being specially designed to test the strength of the framing. The angle of impact was practically normal in all cases.

The first shot was fired from a 10-inch breech-loading rifle. The projectile was a Carpenter shell (weight about 500 pounds), hardened to 2.5 inches below bourrelet, with a charge of 140 pounds of powder. The distance from the gun to the armor was 388 feet; the striking velocity of the projectile was 1432 feet per second. This gave a total striking energy of 7622 foot tons, or 286 foot tons per ton of armor, being 1.29 times the energy required to just penetrate a wrought iron plate of same thickness. The shell struck the plate 71 inches from left edge, 27 inches from top bevel, immediately in front of bulkhead No. 4, between armor bolts *K*, *H*, *L* and *I*, and 8 inches above the center line of second row of armor bolts. The projectile broke up, the head to 6 inches from point remaining welded in the armor, and the balance of the projectile being broken into many small pieces, which were scattered to great distances.

The armor was penetrated 3.75 inches, as shown in Figure 8, the diameter

Figure 4.—Condition of Plate.

of shell metal in impact being 10 inches. The diameter of splash was 14.5 inches. There was not front bulge or fringe; back bulge not visible, but probably very slight. No cracks whatever were developed in the armor, and the wood backing seemed uninjured.

The framing suffered practically no damage, only one rivet in the angle in compartment No. 11 being sheared. All the 1.25-inch tap bolts binding the armor deck to top of armor were sheared, due to the fact that in the target structure there was an imperfect fit between the armor and the plating representing the armor deck, thus permitting the former to move slightiy relatively to the latter. This has been obviated entirely in the actual structure of the ship.

The second shot was fired from the same gun, being a similar shell, but with a charge of 217.2 pounds, giving a striking velocity of 1856 feet per second. The

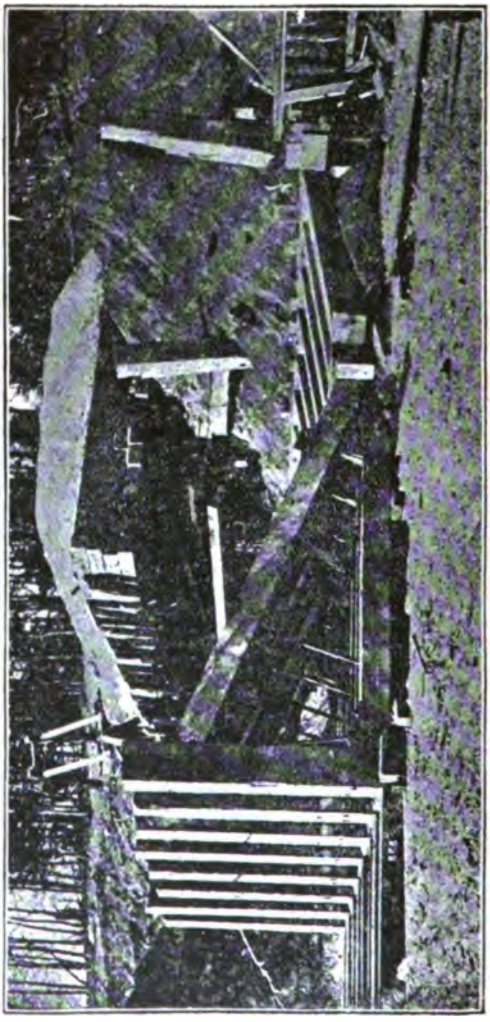


Figure 5.—Method of Supporting Target.

corresponding total striking energy was 11,954 foot tons, or 448.6 foot tons per ton of armor, being 2.3 times the energy just necessary to penetrate a wrought iron plate of same thickness. The shell struck the armor 45 inches from left edge, 29.5 inches from top bevel, and 25 inches from impact No. 1, in front of lower part of compartment No. 3, just to the left of bulkhead No. 3, and 6.5 inches above center line of second row of armor bolts, near bolt *F*.

The projectile broke up at the bourrelet, the head remaining in the armor and pieces of the body and base being scattered around in front of the target. The armor was penetrated 11 inches, the diameter of shot hole being 13 inches. The armor splashed and flaked 17 inches by 18 inches. There was a front bulge ½-inch high and 17 inches diameter. The fringe was very slight, with fine cracks in it. The back bulge was not at this time determined, but the plate in rear of armor and backing was found to have bulged slightly, though

it was not craked. The backing was in good condition, except slight splits at edges of one of the timbers. Armor bolt F was driven to the rear, the end which was screwed into the armor having the threads stripped on side nearest

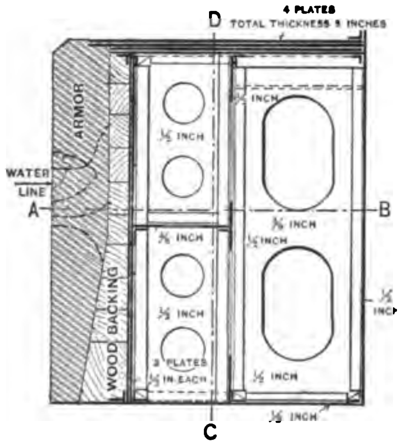


Figure 6.—Transverse Section of Target.

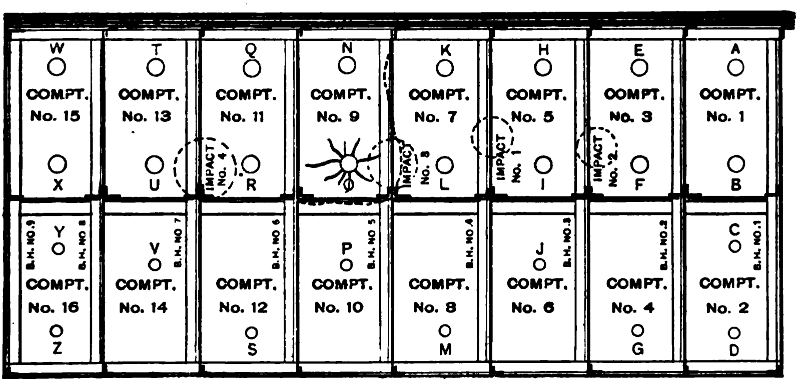


Figure 7.—Section on Line C D of Figure 6.

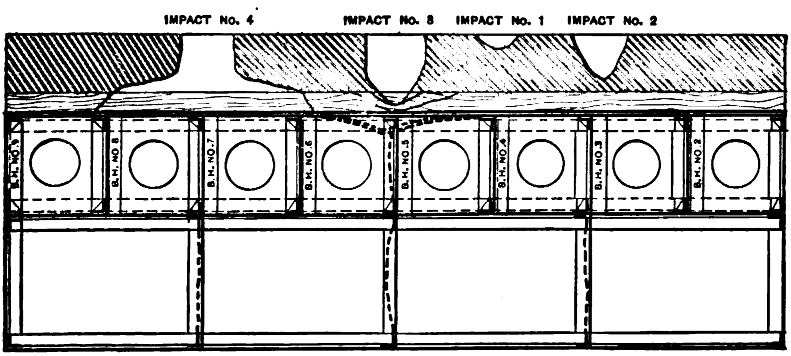


Figure 8.—Section on Line A B of Figure 6.

projectile. No damage whatever was inflicted on the framing; though, owing to a slight deformation of the armor, some of the armor bolt fittings became somewhat slack.

The third shot was fired from a 12-inch breech-loading rifle, the projectile being a Wheeler Stirling armor piercing shell (weight about 850 pounds), hardened to 2 inches below bourrelet, with a powder charge of 400.6 pounds. The striking velocity was 1800 feet per second, giving a striking energy of 19,114 foot tons, or 717.23 foot tons per ton of armor plate, being 2.69 times the energy just necessary to penetrate a wrought-iron plate of same thickness.

The projectile struck the armor 95 inches from right edge, 27.5 inches from impact No. 1, and 33 inches from the top bevel, directly in front of bulkhead No. 5, the point penetratiug 3.75 inches through the plate. The shell broke up below bourrelet, at about 15 to 18 inches from base, set up and cracked longitudinally from base to bourrelet, the two portions of body and base falling in front of target. The head of shell remained in the shot hole, the point and 3 inches of ogive being detached and carrying the back bulge into backing in rear of armor.

The diameter of the shot hole was 13.75 inches, and the diameter of splash in flaking was 20 inches. There was a front bulge ½-inch high and 2 feet in diameter; fringe slight and cracked around shot hole. A portion of the armor on left side of shot hole was nearly detached. The plate was through cracked from top to bottom, through the impact, and was also partially cracked from this impact to impact No. 1 and to the left of same impact to impact No. 2. The ends of the armor plate moved 1.25 inches to the front and away from the framing. There was no movement in the framing itself. In Figs. 7 and 8 is shown the damage inflicted on the framing by this shot.

The framing of bulkhead No. 5 between compartments Nos. 7 and 9 was buckled 3 inches to the right at the top, and a similar amount to the left at the bottom. The connecting angle iron in lower right-hand corner of compartment No. 7 was bent to an angle of 90 degrees at a point 2 inches from the plating behind armor, but none of the rivets in the angle iron were sheared. The plating behind armor and backing in compartment No. 7 and in the vicinity of impact No. 3 was driven to the rear 2 inches: while in the rear of the impact it was locally bulged 5 inches, carrying with it armor bolt *O*, which was sheared off by the blow. The fractured armor bolt having been knocked out with a sledge hammer, showed the wood backing compressed to 1 inch on the right side of this bolt hole, while it was of normal thickness on the left. The rear portion of bulkhead No. 5 buckled 2.5 inches at the middle and somewhat less at top and bottom, the rear portion of bulkhead No. 7 buckled ¾ inch and the rear portion of bulkhead No. 3 buckled 1 inch near bottom. The middle horizontal plate between bulkheads Nos. 5 and 6 was buckled ½-inch. Four flush rivets in the ½-inch backing plates, together with the heads of three rivets in one of the angle irons, were sheared off. No other rivets were broken.

Although this projectile actually penetrated the armor, the damage to the framing, as above specified in detail, was trivial; and, so far as the framing was concerned, no repairs whatever would have been needed to enable it just as efficiently to withstand a second blow of this energy had the armor plate not been cracked through. The framing thus fulfilled, and even exceeded, the first condition laid down—that it must suffer no material damage from any shot not fully penetrating the armor.

The fourth shot was fired from a 13-inch breech-loading rifle at a distance of 378 feet, the projectile being a Wheeler-Stirling shell (weight about 1100 pounds), hardened to a rear part of bourrelet, with a powder charge of 484.2 pounds. The striking velocity was 1800 feet per second, giving a striking energy of 24,763 foot tons, or 1903 foot tons per ton of armor (considering, in this case, only the detached portion of armor plate struck by this shot), being 3.46 times the energy just necessary to penetrate a wrought-iron plate of the same thickness. The projectile struck the armor plate 39 inches from extreme top of plate, 8.5 inches above bevel line, and 45 inches to right of impact No. 3 and 48 inches from right edge.

The projectile penetrated armor and framing completely, being found 12 feet in the sand butt in rear of target. The shell was found to have been set up 3 inches in length and increased in diameter 0.55 inch at bourrelet. The diameter of shot hole in armor was 14 inches; interior smooth. There was no splash; the mean diameter of flaking was 27 inches. The front bulge was mostly flaked away, that remaining on the armor being ½-inch high and 27 inches diameter. There was a back bulge, 4 inches high and about 45 inches diameter, broken out all around, two pieces of from 500 to 600 pounds each being carried to the rear and lodging in the framing, while other smaller pieces were carried right through with the shell. The armor plate was cracked through from this impact in an almost horizontal line to impact No. 3, also through cracked from top of impact diagonally to top of plate, and through cracked from left-hand side of impact vertically down to bottom of plate. These cracks and the complete penetration at this impact are well shown in Fig. 1.

The result.—The experiment concluding with this shot, both armor and wood backing were removed from the framing, for the purpose of further examination. The backing was badly splintered and carried away in rear of this impact. The wood backing was next removed from the armor, and Fig. 4 shows clearly the actual damage inflicted on the armor. None of the armor bolts, except those in the line of impact, were injured. This figure also shows the size of the hole cut through the backing plates.

The character of the injury to the framing by impact No. 4 is partially shown in Figs. 2 and 3. Fig. 2 shows the shot hole in the rear plate of the target; the shell used in this impact also appears in this figure. Fig. 3 is a view taken from the interior of the framing and looking out of the front shot hole after the armor was removed. It shows the two backing plates ruptured and folded back against the bulkheads. The appearance of the rupture speaks well for the quality of the material.

A detailed examination of the framing after the armor and backing had been removed showed the following effeect of all four shots:

Measured at the center line, the face of the structure as a whole was bulged inward away from the straight line connecting the two ends about 2 inches. There was no damage to the plating caused by the two 10-inch shots except a bulge 12 inches diameter and 2 inches high in rear of impact No. 2. Opposite impact No. 3, the two ½-inch plates behind the wood backing were indented 5 inches by the back bulge of the armor, this indentation extending over an area about 3 feet in diameter. Of these two plates, the one next to the backing contained a continuous crack in the indented surface extending from the bolt hole *L* to bolt hole *O*, thence upward and to the left 18 inches, almost following a line where the back bulge was broken out. In rear of impact No.

4, these two plates were broken out, making a hole 44.5 inches by 51.5 inches, the ragged points of the metal being folded inward at a sharp angle on the left side, the plating being cracked at the angle. This plating, the vertical bulkhead No. 7, and the rear bulkhead of target structure in rear of this impact were turned, twisted, bent and fluted, the plates being twisted into all sorts of shapes, exhibiting the fine quality of the metal. The holes in the bulkheads were very much larger than the diameter of the shell. Bulkhead No. 7 was cut off 36 inches from bottom and about 12 inches from top. The plates forming the rear part of framing bulged out 19 inches to the rear and were cracked through, the plate being split and bulged over an area of 42 inches wide by 105 inches long, the rivets binding these plates together being sheared over a length of 106 inches.

The upper portion of bulkhead No. 8 was bent to the right 3 inches, and slightly warped; the upper portion of bulkhead No. 6 was twisted to the left about 5 inches, and badly buckled. The intermediate vertical stiffening plate, ½ inch thick and 12 inches wide, was broken through in rear of impact, and carried away between bulkheads Nos. 5 and 8. The similar upper stiffening plate was bent to the rear about 7 inches between bulkheads Nos. 6 and 8. The deck beam at bulkhead No. 7 was uninjured. Bulkhead No. 5 was slightly buckled, the injury to this bulkhead by impact No. 3 having been slightly increased by this impact. Armor bolt *U* in rear of impact No. 4 fell out from back bulge, broke through and dropped to the bottom of compartment No. 14, the bolt being uninjured except that the portion which screwed into the armor was slightly bent.

Armor bolts *V*, *S*, *Q* and *T* were in place and practically uninjured. Armor bolt *R* was sheared at rear surface of plate and thrown to the rear into compartment No. 12. All the timbers of the backing were loosened up and moved away from the plate, the caulking being loosened around the armor bolts. Eight of the backing timbers were crushed and broken in two in rear of back bulge of impact No. 4 and six of them in rear of back bulge of impact No. 3. The plate and target structure moved to the rear 2 inches. None of the fastenings securing the plate and structure to the wooden target structure were injured. One of the vertical timbers in rear of target was cut in two by the projectile, but remained in place, its inclined brace directly in rear being carried away for a length of 48 inches, the lower part of it remaining in place.

This detailed statement of the injuries inflicted, together with the engravings, shows clearly the extent of the damage. While the injury was very serious behind impact No. 4, where the shell penetrated completely, the important point to note is that it was nearly local, plates and angles a short distance on either side of this impact being practically uninjured; thus satisfying the second condition above stated as requisite. The framing thus, on the whole, showed the effectiveness of its design and clearly demonstrated its complete efficiency for its intended purpose. This test is the most important one that has ever been made, at least in our service, to settle the much discussed question of strength of framing; and it is naturally a great source of satisfaction to all interested in naval affairs to feel that what has been done in the design and construction of such framing in our various ships has been well done, and that no apprehension need be felt on that score. The thoroughness and satisfactory nature of this experiment were due to the cordial co-operation of the Bureaus of Ordnance and of Construction and Repair of the Navy Department, to both of which I am indebted for data and

photographs which have been of the greatest assistance to me in the preparation of this paper.

—*The Iron Age*, November 14, 1895.

b. Armor and Projectiles.

Test of a Johnson Shell—United States.

A remarkable result attended a test of armor-piercing shells at the Indian Head proving grounds yesterday. Two of the three shells submitted fulfilled the requirements of the trial, but the other completely penetrated the target, going straight through the heavy backing and entering a dirt bank for the distance of fourteen feet. The shell that proved so successful is that of the Johnson Company of Spuyten Duyvil, N.Y., and what made its accomplishment more surprising was the fact that its cap or point was composed of soft steel, while the shell itself was of cast-iron. It overturned existing theories. The target was a Harveyized armor plate, seven inches thick, and the shell was of six inches caliber.

A second test of a plate, representing a group of the battle ship *Iowa's* barbette armor, also took place yesterday. It was merely for the purpose of affirming what the first test had shown—that the plate was good. Several shots from a 12-inch gun were fired and went to pieces on the plate, which was fifteen inches thick.

—*New York Sun*, February 27, 1896.

Tests of a 0.625-inch face-hardened plate.

The Navy Department has received reports from Ensign Williams and Lieutenant N. E. Mason of a test of a Carnegie thin shield plate ⅝ of an inch in thickness and face hardened. The width of the plate was 34 inches and its length 48 inches. The plate was fired at fourteen times with 1-pounder projectiles. Lieutenant Mason sums up the results: "This plate when inclined at an angle of 40° will keep out 1-pounder piercing projectiles fired with a muzzle velocity of 1750 feet per second, at ranges greater than 105 yards, when the impacts are above the supports, and at ranges greater than 240 yards when the impacts are between or near the supports. When the line of fire is normal to the surface of the plate, it will keep out the same projectile at ranges greater than 1975 yards." Ordnance experts regard the results obtained from the plate as excellent. They are waiting for the test of the Bethlehem thin steel plate, which will be made shortly. When this test is completed, Captain Sampson, Chief of the Bureau of Ordnance, will adopt the plate giving the best results as the type to be used in the naval service.

—*Army and Navy Journal.*

c. Powder and Explosives.

Rosslyn Smokeless Explosive.

This new smokeless explosive is the one we referred to in our October, 1895, issue as having been produced by Messrs. Hay, Merricks, & Co., Limited, of the Rosslyn Gunpowder Works, Scotland. Its peculiar characteristic consists in the fact that it is made up in the form of a woven or netted web of textile fabric, and not in the usual shape of grains or rods. In the preparation of the explosive, the web, either scoured and bleached or left untouched (though in the former case a more stable material is the result), is nitrated by any of the known methods, and washed until it stands the "heat test." It is then rendered suitable for use in fire-arms by the introduction of any or all of the

following modifying agents in solution: Barium nitrate dissolved in water, sodium nitrate dissolved in water, potassium nitrate dissolved in water, ammonium nitrate dissolved in water, starch dissolved in water, nitro-glycerin alone, nitro-glycerin dissolved in any suitable solvent, paraffin or vaseline dissolved in benzine or in any other suitable solvent. After this process the solvents are dried out, and the finished explosive is left in the form of a nitrated cloth, containing the substances referred to above, partly within its cellular structure, and partly within its netted interstices. Its condition in this finished state is one that lends itself for cutting into pieces or strips varying in size and weight according to the explosive effect desired. Patent accepted September 28, 1895.

—*Arms and Explosives.*

New Smokeless Powder.

The International Powder Company (American) has brought out a new powder. The patent specifications state that it is composed of nitro-glycerin, trinitrocellulose, a nitrate neutralizer of free acid, and a deterrent such as vaseline or a resin; the proportion of nitrate to the trinitrocellulose being about forty-five parts of nitrate to one hundred of cellulose. The use of the fossilized gum Kauri is also claimed.

—*United Service,* March, 1896.

d. Torpedoes.

A "Fougasse."

The picture of how a *fougasse* should be prepared will occur to the minds of many who have read books on military engineering, but records of any actually fired are rare.

In the course of field instruction of the Battalion of Engineers at Willet's Point, N.Y., during the autumn of 1895, one was tried.

The powder available was poor mortar powder valued at four cents per pound.

The site chosen was one end of the ditch, eight feet deep, of a siege battery.

The full line (see sketch) give the profile of the parapet (traverse) and ditch as constructed; the broken line indicates cut and fill for the fougasse.

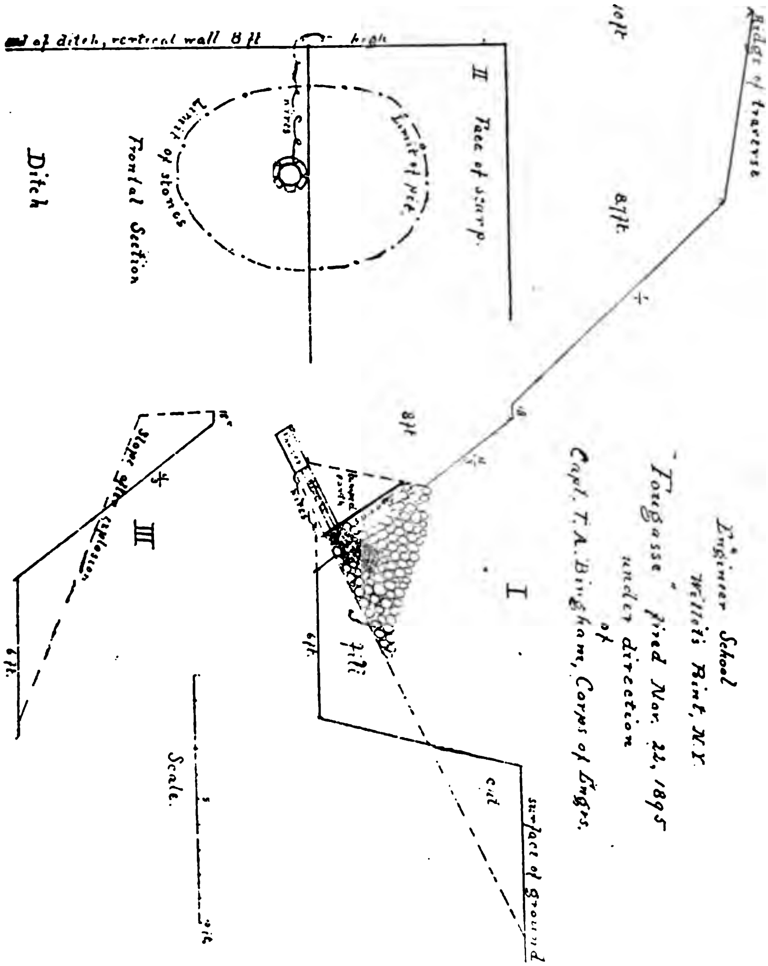
An original can containing 25 lbs. of powder was used, fired by a new Laflin & Rand firing battery.

After making the cut for the mouth of the fougasse, a pocket, just large enough to hold the can of powder was excavated at the rear end of the cut. The can was placed in this pocket and entirely surrounded by strips of wood, of the length of the can, forming a rough sort of barrel around it. These wooden strips were held in place merely by earth tamped around them. These strips thus formed a sort of wooden ribbed powder chamber.

Directly in front of the can and with their ends against it, were placed three pieces of wood about 4″ x 4″ and about three feet long, all roughly cut to the same length. These formed three wooden projectiles in front of the powder but outside of the wooden cannon in which the powder rested. Over these wooden projectiles was solidly tamped earth.

Just in front of these wooden projectiles, touching them and inclined slightly to the rear against the tamped earth was a sort of fence or sheeting of loose boards against which the stones were piled as shown.

Owing to the poor quality of the powder, care was taken to put the smaller stones in and around the axis of discharge, surrounding them by larger stones. The object of this was both to direct the discharge and to make sure that some stones should be thrown at least across the ditch. About 1½ cu. yds. of stones were used in all, varying in size from that of a man's fist to that of his head.



Looking at sketch II the earth behind the fence of boards was tamped hard on the right hand side and not quite so hard on the left hand side, both in order not to injure the lead wires (covered with boards), and also because it was not thought necessary, as the ditch ended here with a vertical wall.

The results of discharge were surprising. If poor powder will do so well, good powder would make "fougasses" formidable devices.

Some of the large stones were thrown sixty to seventy-five feet in the air and as far as 200 yards. The shower of small stones filled the air for 50 to 100 yards from the ditch.

Fired just as a storming party had arrived at the edge of the counterscarp, this fourgasse would have made a gap in their line thirty feet long, and the supports would also have suffered severely.

Captain THEODORE A. BINGHAM,
Corps of Engineers.

e. Range and Position Finding.

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f. Miscellaneous.

Aluminum in 1895.

While there was an appreciable increase in the production of aluminum in 1895 over that of previous years, the output, as for several years past, was from the works of one producer only. The Pittsburg Reduction Company during the year started up its new works at Niagara Falls, taking 4,500 horse-power from the Niagara Falls Power Company. The addition to its facilities enabled the company to turn out 850,000 pounds of the metal, an increase of about 100,000 pounds over 1894. The increase was readily taken up, and the demand for the metal is still beyond the capacity of production. The company has arranged to double the size of its plant and to increase the production accordingly, having contracted for an additional 4,500 horse-power.

No new uses for aluminum were developed during the year. The demand for the pure metal has been largely for the manufacture of small articles and household utensils, the demand for which is increasing. The cost, as heretofore, continues to limit the use.

The production in Europe is still controlled by the Neuhausen Company in Switzerland, which controls the French works as well as its own, and is gradually extending its operations. The production, however, has not yet been much increased, and is estimated at about 50,000 kilo. for the Neuhausen and Froges Works. The British Aluminum Company, which purposes making the metal from Irish Bauxite, has not completed its works, and it is uncertain when it will become a producer.

—*American Manufacturer*, January 24th, 1895.

Nickle in 1895.

The chief use of this metal has continued to be as an alloy in the manufacture of steel, the demand in this direction having still felt the impetus given by the very successful tests of armor plate made of nickle-steel in different countries.

The production of nickle in the United States from native ores has practically ceased, and nearly or quite all the nickle refined or consumed in this country is of Canadian origin. The other sources of nickle supply are the French colony of New Caledonia and Norway, the production of Sweden, which at one time was of some importance, having practically ceased. The amount imported into this country from Canada in the form of matte (all refined here) shows a falling off from 1894, the figures being 3,138,400 pounds for 1895, against 4,897,191 pounds in 1894. With the Russian contracts already secured for armor plate by manufactures in this country and the certainty of increase in our own consumption for the same purpose, the demand is sure to become greater, and the lower price makes the metal just so much more available as an alloy with steel. In spite of a rumored agreement between the French company controlling the New Caledonia supply and the refiners in this country to maintain the price and probably raise it, the present low

figure of 25 cents in large amounts will tend to extend its use, and recent improvements in refining cheapening very materially the cost as hitherto treated will tend to keep down the price.

—*American Manufacturer*, January 24, 1895.

FORTIFICATIONS.

Defensive System of Switzerland.*

The fortifications erected in Switzerland in the last four years have a twofold interest for the engineer first, because they relate to the general problem of the defence of states, and secondly, because they illustrate the practical dispositions for the defence now in vogue in the military engineering profession. Under the first aspect especially, we will here briefly describe, following the *Revue Militaire de l' Etranger*, the fortifications erected in Switzerland during the past four years.

The key to the defence of Switzerland is the Saint Gothard. Hence it is around the Saint Gothard that Switzerland has established her principal fortifications.

Viewing these works merely as to their matériel they are important, since their cost has reached something more than eleven million francs.

For the sake of clearness, these works may be divided into five groups. Following out this scheme, the five groups can be considered as forming two straight lines. On the first line running nearly north and south are: 1°, The Airolo group; 2°, the central Saint Gothard group; 3°, the Andermatt group. On the second line extending nearly east and west are the Furka and the Oberalp group.

As a matter of fact, the position of the second line varies a little from perpendicularity to the meridian. It conforms to the direction of the upper Reuss, which makes a marked angle with the parallel, obliquing towards the north east.

The Furka group consists of two works, the Galenhütten battery and the small fort of Furka, designed to control the valley of the Rhone, which begins at Furka.

The Airolo group, more important than the preceding, consists of five works. The principal work, Fort Fondo del Bosco, commands the valley of the Ticino, and covers the débouché of the Saint Gothard tunnel. It is furnished with sixteen pieces of artillery, and is surrounded by a moat 10 meters (32.8 feet) deep, with reveted scarp and counterscarp. A battery at Motto-Bartolo and a gallery at Stucci, to the east of the two preceding works, flank them from a distance. There are also two blockhouses here, completing the Airolo group.

Behind the Airolo group, four kilometers (2½ miles) to the north is the central Saint Gothard group, consisting of four works. The chief one of these is the fort of Saint Gothard, flanked by the trenches of Bianchi, by the blockhouse of Cavanna, and by the blockhouse of Pusmeda. It is provided with only one cannon, showing that it is of far less importance than Fort Fondo del Bosco, placed on the first line.

The Oberalp group is composed of the redoubt of Calmot and the position of Grossboden, which are intended to command the valley of the Rhine. Last of all is the Andermatt group, the most substantially organized of all,

* This article is worth studying with the assistance of a large map.—ED.

comprising the fort of Bühl, the fort of Boetzberg, the flanking gallery of Altkirch, the position of Rossmetten and the blockhouse of Brückenwaldboden.

The Andermatt group is 10 kilometers (6¼ miles) to the north of that of the Central Saint Gothard, 17 kilometers (10½ miles) east of the Furka group, and 8 kilometers (5 miles) west of the Oberalp group. These distances are measured as the crow flies, and are far less than the distances measured along the zig-zag roads that join these four groups of localities.

These five groups of works are interesting from another point than that of masonry and arches; they are to be garrisoned by permanent troops, a new thing in Switzerland. These troops are made up of two battalions of infantry, and four companies of artillery, all picked troops, and are reinforced by six battalions of infantry from the *Landwehr*, three companies of artillery, and three companies of engineer troops (sappers), likewise from the *Landwehr*.

In addition to these five groups of works constructed at the Saint Gothard, the Swiss have established fortifications at Saint Maurice, in the valley of the Rhone, to the west of the Saint Gothard position. The fortifications of Saint Maurice are placed at Savatan and Dailly. These works have cost two million francs, and are occupied by a permanent garrison, consisting of a battalion of infantry, and a company of artillery.

Fortifications are also projected for the vicinity of Luziensteig, in the valley of the Rhine, east of the Saint Gothard position.

Of what value for defence are the works erected about Saint Gothard?

This question is difficult to answer; their purpose seems to be the same as that of the forts around Namur and Liège; this much can be asserted, that they manifest a definite intention, on the part of Switzerland, to make her neutrality respected, just as the forts on the Meuse show the same intention on the part of Belgium.

Under the supposition that Italy meant to force the Saint Gothard, co-operating with Austria and Germany, Switzerland would be hardest pressed to guard her neutrality. But even without fortifications, it would be difficult for an army to force the position of the Saint Gothard; and it is certain that with permanent magazines, cannon in place, and garrisons already mobilized, its defensive power would be considerably augmented.

Looking at them in this light, as a preparation for war, the new fortifications will constitute a considerable advantage for the defence. These fortifications will be a point of support for the Swiss when operating offensively on the flanks of an invader, whoever this might be, and for maneuvering against his direct lines of communication, should he succeed in turning the fortifications of the Gothard.

The location of each separate work, and the dispositions adopted, looking at them from a topographical standpoint, show very careful study. The sites chosen are tactically inaccessible, and their fire commands the narrow roads of approach that skirt the Saint Gothard tunnel, the probable objective of the Italian army, in case it purposed violating Swiss neutrality.

It would be useless to discuss the contrary hypothesis, that in which the violator of Switzerland's neutrality was the adversary of Italy. In the present state of Europe, this supposition is too improbable to deserve consideration. France has no surer alley than Switzerland, and would have nothing to gain by violating her neutrality.

L'Avenir Militaire, January 10th, 1896.

[G. B.]

MILITARY GEOGRAPHY.

Deep Waterways—The Connecting Waters Between Lakes Huron and Erie.

Although it is not expected that the deep water channel of the lakes in all its parts, including St. Mary's Falls canal, will be entirely completed until the opening of navigation in 1897, lake vessels will be afforded great advantages in using parts of this new waterway during the coming season. In some cases, whole sections of the 20 and 21-foot channel are now completed; others will be entirely finished within one to three months after the opening of the coming season, and others still will be completed as regards part of their width, so that advantage may be taken of the full draft which they will afford, although not the full width.

This is especially true of sections of the work between Lakes Huron and Erie, or in other words, the channels that will be used by vessels in the Lake Michigan trade. With a view to showing the progress of work in all of the connecting waters between Lakes Huron and Michigan, the *Review* presents as a supplement to this issue a chart showing the present state of these improvements. The drawing was made by Mr. Edward Molitor, who has for a number of years past been engaged on work of this kind in the United States engineer office, Detroit, Michigan. Permission to make this drawing was granted by Lieutenant Cavanaugh, corps of engineers, U. S. A., who is in charge of the Detroit office, and the *Review* is indebted to Lieutenant Cavanaugh also for all information contained in this article. The main object in having this chart prepared is to show that shortly after the opening of navigation next season all sections of the 20 and 21-foot channel between Lakes Huron and Erie will be available to vessels drawing 20 feet of water, at normal stage, but unfortunately a great deal of dredging and rock blasting is yet to be done between Ballard's reef and Lime-Kiln crossing, Detroit river, and also in the Canadian channel between Amherstburg and the lower end of Bois Blanc island, Detroit river. These places are not covered by the big channel contracts. The work of dredging in the vicinity of Ballard's reef is dependent upon appropriations aside from those for the 20 and 21-foot channel between Chicago, Duluth and Buffalo.

At the present time a channel 600 feet wide has been cleared of obstructions to a depth of 18 feet at the normal stage of water, from Ballard's reef to Lime-Kiln crossing, the axis of the channel being the lower Grosse Isle range lights. The eastern half of this channel, 300 feet wide, is now being dredged to a depth of 20 feet, while the western half is open to the use of vessels. After the eastern half has been completed to the full depth of 20 feet, which will be done probably about the first of September, it will be thrown open to the use of vessels during the time the western half is being dredged to full depth of 20 feet. The completion of the western half to full depth of 20 feet will give a channel 600 feet wide and 20 feet deep at the normal stage of water, as proposed, but the whole improvement will not be finished before the end of the season. In the channel between Amherstburg and the lower end of Bois Blanc island there are a number of obstructions having but 17 feet of water over them at the normal stage. This part of the river was to have been improved by the Canadian government and dredges were to have been put on last season, but as yet no steps have been taken for the removal of the obstructions, and as this will soon be the only part of the

deep channels where obstructions reach above 18 feet, the United States will have to take the necessary steps for the removal of these obstructions, unless the Canadian government does so, in order that full advantage of other improvements may be obtained. With the completion of the eastern half of the channel between Ballard's reef and Lime-Kiln crossing, about the middle of next season, these obstructions will become even more serious, for they will lessen, by from 2 to 3 feet, the depths otherwise available.

Now as to what may be expected shortly after the opening of navigation next season. In 1895 the loss to vessels in carrying capacity on account of low water was the greatest ever known, but there were times, however, during the period of best water when vessels from Chicago and Escanaba passed through the river drawing full 16 feet. The great difficulties encountered by these vessels were met at Grosse point and at Ballard's reef. Next season about 1800 feet at the lower end of the Grosse point section of the new channel, from the 19-foot contour in Lake St. Clair into Detroit river will, shortly after the opening of navigation, be available to traffic, giving an available depth of 19 feet through Lake St. Clair. Conditions at Ballard's reef, where there is now available a channel 300 feet wide and 18 feet deep at normal stage, (i. e. the western half of proposed channel) will remain unchanged until the eastern half is completed to the full depth of 20 feet, giving a channel 300 feet by 20 feet, about September 1, 1896; but it is unfortunate that little if anything more than 17 feet may be expected in the Canadian channel between Amherstburg and the lower end of Bois Blanc island. It is reasonable to expect, however, that with any improvement at all in the waters of the lakes generally, full 17 feet draft will be afforded vessels in the Lake Michigan trade. Firms owning vessels and controlling docks at Ashtabula are accordingly preparing for 17 feet draft in the rivers, and they propose to provide a similar draft in Ashtabula harbor, where dredges were at work the greater part of last season, and will again begin operations at the earliest opportunity in the spring.

The situation is different as regards Lake Superior. For the trade through the Sault canal, there is, of course, no hope of increased draft, excepting such as may be derived from a natural increase of water levels, until the new canal is in readiness in the spring of 1897. Then, too, there is one section of the 20 and 21-foot channel in the Sault river—section 3 at Sailor's Encampment—upon which there is a great deal of dredging yet required. But it is now certain that all parts of the 20 and 21-foot channel work proper will be entirely completed during the coming season, as the condition of the work at present is as follows: Section 1, (two shoals near Round Island, above Sault Ste. Marie) is done; section 2, (Little Mud Lake and Dark Hole, Sault river) is practically completed; section 3, (Sailor's Encampment, Sault river) is well along towards completion and will be finished during 1896; section 4, (head of Mud Lake, Sault river) is completed; section 5, (foot of Lake Huron) not entirely completed but eastern half, 1,200 feet wide and 21 feet deep, available for traffic; section 6, (St. Clair Flats) is completed; section 7, (Grosse point, foot of Lake St. Clair) not entirely completed but lower 18,000 feet, giving a 19-foot navigation, can now be made available for traffic and entire section will be finished shortly after the opening of navigation in 1896; section 8, (mouth of Detroit river) not entirely completed, but available for traffic and will be finished shortly after opening of navigation in 1896.

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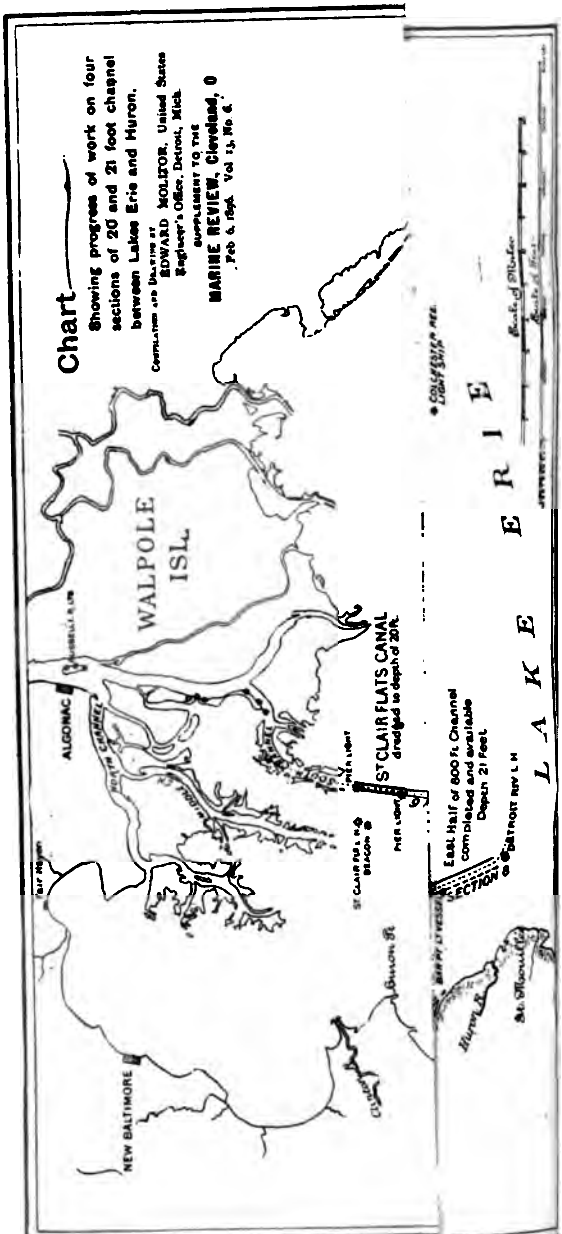

feet of water at normal stage next season for vessels in the Lake Michigan trade, it may be said in a general way that there is not now a single harbor on Lake Erie that will admit vessels of that draft. Ashtabula harbor will afford such a draft shortly after the opening of navigation, but even at that point there is danger of the mouth of the harbor filling up with sand unless constant dredging is resorted to. The information contained in this article tends to show, however, that the deep-water channels are gradually approaching a reality, and municipalities, dock corporations and other interests will certainly make short work of fitting the harbors of Lake Erie for 18 or 20 feet draft, if the work in connecting rivers of the lakes turns out to be all or nearly all that is expected of it. One other point must be borne in mind by vessel owners. If expectations regarding this deep draft are realized, there are a great many steel vessels now in commission that must be strengthened and otherwise prepared for it.

—*Marine Review*, February 6 1896.

WAR SHIPS AND TORPEDO BOATS.

The Fleets of the Great Nations.

The *Carnet de poche d'officier de marine* contains a classified list of the fleets of the great nations, according to which, taking into account only the latest types, England, Italy, Germany, Austria, Russia, France and the United States possess the following ships:

Armored vessels :—

(1) Battleships of 13,000 tons and a speed of at least 18 knots: England 7; 10,000—13,000 tons and at least 16 knots: England 11, Italy 4, Germany 4, Russia 3, France 6 and United States 3; 8000 tons and from 14 to 16 knots: England 11, Italy 3, Germany 1, Russia 6, France 7, and of less than 8000 tons and less than 16 knots speed: England 1, Germany 9, Austria 4, Russia 1, France 4, United States 1.

(2) Coast-defense ships of 8000 tons and at least 16 knots: England 2: 6000–8000 tons and 14–16 knots: England 2, France 9, and of less than 6000 tons and 14–16 knots: England 1, Germany 6, France 2, United States 2.

(3) Armored cruisers of 4000–6000 tons and at least 18 knots: England 9, Russia 3, France 5, United States 2.

(4) Armored gunboats or monitors of 1500 tons and at least 13 knots: Austria 2, Russia 3, France 8, United States 1.

Other armored vessels: Italy 3, France 5.

Total armored vessels of the latest type: England 44, Italy 10, Germany 20, Austria 6, Russia 16, France 41, United States 9.

Unarmored vessels :—

(1) Protected cruisers and torpedo despatch boats of 8000 tons or more and at least 18 knots: England 2, Russia 1; 4000–8000 tons and at least 18 knots: England 21, Italy 1, Germany 5, United States 8; 4000 tons and 14–16 knots: England 7, France 3; 2000–4000 tons and at least 17 knots: England 31, Italy 13, Germany 1, Austria 2, Russia 3, France 5, United States 6; 2000–4000 tons and at least 14 knots: England 6, Italy 4, Germany 7, Russia 8, France 12, United States 2, and of less than 2000 tons and 14 knots or over: England 19, Italy 5, Germany 17, Austria 1, Russia 10, France 7, United States 8.

(2) Torpedo cruisers of 20 knots and over: Italy 8, Russia 6, United States 1: of 15-20 knots: England 9, France 4.

(3) Torpedo-boat destroyers of at least 25 knots: England 11, Italy 5, Germany 4; of 20 to 22 knots: England 11, Italy 1, Germany 6, Austria 6, France 19.

Other unarmored vessels: England 21, France 1, Russia 4, Italy 6 and Austria 6.

Total unarmored vessels: England 138, Italy 43, Germany 40, Austria 15, Russia 32, France 51, United States 25.

Torpedo boats:—

Torpedo boats of 120 tons and from 20 to 25 knots: England 2, Germany 15, Russia 17, France 9, United States 1; of 100 tons and at least 20 knots: England 10, Italy 2, Germany 18, Russia 3, France 21, United States 1; of 40—100 tons and at least 20 knots; England 54, Italy 92, Germany 59, Austria 22, Russia 23, France 149, United States 1; of 40—100 tons and at least 18 knots: England 12, Germany 25, Austria 34, Russia 10, and of less than 40 tons and at least 18 knots: England 27, Italy 57, Russia 2, France 37.

Total torpedo boats: England 105, Italy 151, Germany 117, Austria 56, Russia 55, France 216, United States 3.

Grand total:—

The total number of vessels of latest type is, therefore,—England 287, Italy 204, Germany 177, Austria 77, Russia 103, France 308 and United States 37.

Besides these there are a number of armored vessels of older type, which will be available for defensive purposes as well as in second line. Of these England has 21, Germany 14, Austria 5, Italy 4, France 9 and United States 18.

—*Allgemeine Militär-Zeitung*, January 24, 1896.

GENERAL MILITARY MATTERS.

The Study of Foreign Languages by Officers—Bavaria.

As an indication of the energy with which the study of foreign languages is carried on in the corps of officers we are informed that thus far *all* the officers studying at the War Academy have decided for the study of foreign languages (namely French, English and Russian), notwithstanding the fact that they have the choice between languages and mathematics. Of course, the fact that a knowledge of at least *one* foreign language is an essential qualification for entrance into the General Staff has something to do with this state of affairs. But, even at the ordinary posts many young officers are studying languages in order to take part in the annual competitive examinations for interpreters.

[M.N.N.]

—*Allegemeine Schweizerische Militär-Zeitung*, January 25, 1895.

BOOK NOTICES.

The Century Dictionary, an Encyclopedic Lexicon, 1891, and the Century Cyclopedia of Names, a pronouncing and etymological dictionary of names in geography, biography, mythology, history, ethnology, art, archæology, fiction, etc., 1894-5. The Century Company. Seven volumes, $10.00 per volume.

Dr. Johnson in the preface to his Dictionary remarks:

"I am not so lost in lexicography as to forget that words *are the daughters of earth, and that things are the sons of heaven.*"

There are dictionaries of things, which are more properly cyclopedias, and there are word-dictionaries, which are dictionaries proper. The dictionary before us combines the characters of both. It is a general dictionary of the English language serviceable for practical as well as literary use; it goes far beyond any other dictionary in the addition of a great number of modern scientific and technical terms and many provincial and dialectal words; and finally it makes free use of excellent illustrations and much explanation of *things* in addition to that of *words* proper.

Murray's New English Dictionary on Historical Principles differs from it in that it does not, like the Century, *dictate* to usage, but merely *records* usage, giving an account of the various forms in which each word appears since the formation of the language, or since the introduction of the word into the language. Nevertheless, even in this respect, the Century Dictionary is ahead of all others, giving all obsolete words of practical use, thus adding a vocabulary which is extremely valuable, for example, in reading the older poets, like Chaucer.

The Century addresses itself more directly to the demands of general use. In the large addition of new words it has acted on the principle that it is better to err on the side of broad inclusiveness than of narrow exclusiveness.

"In words, as fashions, the same rule will hold,
Alike fantastic if too new or old;
Be not the first by whom the new are tried,
Nor yet the last to lay the old aside."

Pope—*Essay on Criticism.*

When it is remembered that in the *Eucyclopædia Brittanica* alone the editors found ten thousand words not contained in any dictionary printed at that time, it is evident that there was some need for greater comprehensiveness, and good authority for many new words.

But, in this addition the aim has not been merely to gather words. The new words still bear the stamp of authority, for they have been selected by scholars, and those that do not possess a purely historical, etymological or literary importance, yet have a scientific or practical value. In all about two hundred and fifteen thousand words are defined.

The editor-in-chief of this great work was Professor William D. Whitney of Yale University, perhaps the highest authority in the world in philology, assisted by six able assistant editors; and among the editorial contributors may be mentioned Professor Josiah D. Whitney of Harvard University, Professor Edward S. Dana of Yale University, Lyman Abbott D. D., Professors

Theodore N. Gill and Frank H. Knowlton of the Columbian University, Professor Robert H. Thurston of Cornell University, and Professor J. Franklin Jameson of Brown University, and a score of others of equal prominence. The naval and nautical terms were edited by Commander Francis M. Green of the Navy, and the military terms by Captain David A. Lyle of the Army.

Webster's International Dictionary is still the most serviceable authoritative dictionary, as it is complete in one volume, but the easy terms of payment made by the publishers place the *Century* within the reach of all. It has taken its place as our standard dictionary, and to-day no student who makes great use of a dictionary can well dispense with it.

We have had occasion to examine carefully every military term in the first two volumes and can vouch for the general accuracy of the definitions as well as the comprehensiveness of the vocabulary.

The illustrations are excellent, both from a technical and an artistic point of view. We have tested the work in this respect on the subject of fishes and find that they are quite sufficient to give the general reader a good idea of all the common forms of fishes and of the types of all the rarer forms.

The Cyclopedia of Names is an outgrowth of *The Century Dictionary*, an enlargement of its encyclopedic character, and to the ordinary reader, who strives to keep himself informed on matters of daily conversation in the intellectual and social world, and who reads mainly for pleasure and entertainment, it is even more valuable than the *Dictionary* proper. The names comprise names of biography, geography, races, tribes, mythological and legendary persons and places, characters and objects in fiction, stars and constellations, academies, universities, clubs, wars, battles, treaties, warships, yachts, horses, etc.

It was edited by Benjamin E. Smith, A. M., the managing editor of the *Dictionary*, assisted by a number of eminent specialists.

J. P. W.

History for Ready Reference and Topical Reading, from the best Historians, biographers, and specialists; their own words in a complete system of history. J. N. Larned.—The C. A. Nichols Co., Springfield, Mass., in five volumes, $5.00 per volume.

Among the great works of reference which have appeared in the past few years this stands out prominently as unique in design and execution. The author set for himself a stupendous task, which he has performed with wonderful success. It could only be accomplished by years of patient labor, and as superintendent of the Buffalo Public Library he has been enabled to combine this work with his daily duties and devote to it the time necessary for his great purpose.

The volumes constitute a general history surpassing every other work on that subject. The general arrangement of the material is alphabetical, so that it resembles a cyclopedia in that respect, but the grouping of the topics is a distinct feature, and one in which the author has shown himself an able workman. The subject matter of each topic is arranged chronologically, but differs again from the cyclopedia in that it is composed almost entirely of extracts from the best histories. None but a librarian of large experience could have produced such a work, and none but a very modest man would have thought of giving the results of this labor in the exact words of the authors themselves, most of them the greatest and brightest scholars that have written on history. These extracts have been selected with good judgment and

put together with great skill, giving the various accounts unity and cohesion as well as comprehensiveness. Not the least of its merits is its *literary* character, for we have here, in these extracts from the world's greatest writers, literature as well as history.

In illustration of the general character of the work, we find under the title "Italy," for example, sixty-nine pages of extracts from such historians as Mommsen, Sismondi, Gibbon, Freeman, Milman, Hallam, Michelet, Guizot, Ranke, Grimm, Bryce, Napier, Symonds, Trollope, and a score of others, together with numerous references to other articles in this work, as well as to other works. The article is illustrated by maps of Italy in the seventh century, in 1492, in 1815 to 1859 and in 1861. It is subdivided into appropriate sections with proper headings, such as "Early Italians," "961-1039,—Subjection to Germany," "1056-1152,—The rise of the republican cities," "1867-1870, —Settlement of the Roman question," "1870-1894,—The tasks and burdens of of the United Nation, Military and Colonial Ambitions, The Triple Alliance," etc. Such an arrangement is evidently of great value for ready reference to a particular branch of a general topic.

The work has also the great merit of being fully up to date, most of the articles containing references to events as late as 1894. The first volume contains in an appendix a most valuable bibliography of history of America and of Austria. The last volume has a supplement of 267 pages, which makes important additions to the articles in the body of the work, contains notes of recent events (1895) and perfects the cross-references by which the whole work is indexed; it comprises, moreover a complete chronology of important and indicative events, tables of lineage of European sovereigns and great historical families, a selected bibliography, and a list of the works from which passages have been quoted. Throughout the several volumes are scattered chronological tables ot contemporaneous events, prepared with great care, which aid materially in obtaining a more general view and a clearer comprehension of the history of an epoch.

History should be the great general subject of study for army officers, and, bearing in mind the comparatively small compass of these five volumes, there is no library of history that can compare with this work. On the other hand, for those who wish to go deeper into special epochs of history, or desire to inform themselves along particular lines, we know of no better guide, or more useful preliminary course of reading. Moreover, its convenient arrangement cannot fail to recommend it to readers who use it mainly for ready reference.

These five imperial volumes of about 800 pages each are illustrated with an excellent series of maps, many of them in colors, and all admirably adapted to the general purpose of the work, viz: conveying accurate information quickly and easily. The paper, typography and binding leave nothing to be desired, and are such as we seem nowadays to have a right to expect from the Riverside Press.

We cannot better express our opinion of the entire work than by quoting the words of one whose opinion on a historical work must command respect,— Dr. John Fiske of Cambridge:

"I believe it will prove one of the most valuable reference books in existence."

J. P. W.

Napoleon Bonaparte's First Campaign. Herbert H. Sargent, First Lieutenant Second Cavalry, United States Army. A. C. McClurg & Company, Crown 8vo. 231 pages with maps. Chicago, 1895. $1.50.

This careful study of Bonaparte's brilliant campaign in Italy in 1796-7, when, at the age of twenty-six, he defeated six Austrian armies sent successively against him, presents the subject in such clear and simple language, with all unimportant operations eliminated, that it constitutes for the general reader a deeply interesting work, and for the military student an exceeding valuable contribution.

The mode of treatment of the subject is modeled somewhat after that of Hamley in his *Operations of War*, but the author has managed to render the subject-matter far more readable than is usually the case in such military essays, and his thorough knowledge of and familiarity with all the details have enabled him to give to the world a really excellent little book. The *comments* are clear, accurate and to the point, and have been so carefully made that there is hardly an opportunity for any contradiction or difference of opinion, and the author has succeeded in presenting them in a form easily comprehended and in a manner such as to render them highly instructive.

We cannot better illustrate the author's simple style and the interest of the narrative than by quoting a few passages:

"Again the Austrians were re-enforced. Again they attempted to relieve Mantua and to drive the French from Italy. With that fatal persistency in error that Wurmser had exhibited in the previous campaign, he divided his forces: leaving Davidovitch with twenty thousand men separated into several detachments in the Tyrol, while with the remainder of his army, twenty-six thousand strong, he was preparing to descend the valley of the Brenta. * * *

"Having received a re-enforcement of several thousand, Bonaparte had altogether about forty-two thousand soldiers. He thought himself strong enough to make an offensive movement. * * * He directed Vaubois, who was at Salo with his division, to march by Riva upon Roveredo; and, with Masséna's and Augereau's divisions, he himself ascended the Adige. Early in September he united these three divisions, numbering about thirty thousand, near Roveredo, attacked Davidovitch, defeated him at Roveredo and Caliano, drove him into the Tyrol, and gained possession of Trent. * * * Until Bonaparte reached this point, he was not aware of Wurmser's departure down the Brenta. He therefore unexpectedly found himself in a favorable position. The Austrian right wing had been overthrown, the left isolated and turned, and he was on its line of retreat. With thirty thousand soldiers he was directly between Davidovich and Wurmser, and the latter had already been defeated. * * *

"Bonaparte left Vaubois in the Tyrol to hold back Davidovich, while with Masséna's and Augereau's divisions he hurried forward to overtake the Austrians. Marching fifty miles in two days, he came up to them at Bassano. At Bonaparte's appearance, Wurmser knew not which way to turn. He had expected to find the French in his front; he found them in his rear. * * * Wurmser * * * was defeated. By this battle, known as Bassano, the Austrian forces were separated. Quasdanovich with the remnants of his division retired into the mountainous district of Friuli, while Wurmser himself with the remainder of his army, numbering about twelve thousand, marched for Mantua."

In the comments on Arcole we find the following remarks:

"It is worthy of notice that during all of his (Bonaparte's) military operations he never allowed himself to be besieged in any place.

"When the commander of an army is hard pressed, and there is near at hand a strongly fortified place with outlying works of great strength, and provisions and water within, the temptation is great to seek security there. Second rate generals accept such opportunities."

The typography and binding of this little book are neatly and tastefully executed; the maps, although somewhat indistinct in places, are sufficient to enable the reader to follow the movements of the troops readily; and, finally, a good index completes the work of the publishers.

It is remarkable what a number of the immutable principles of strategy are illustrated in this, Napoleon's first campaign: for this reason it constitutes an excellent study for military men, and we have no hesitation in recommending this volume to them. But the principles of strategy are only common sense applied to military situations, and are consequently readily understood and appreciated by the general reader; moreover, since "every gentleman should know at least one campaign by heart" we take pleasure in recommending this able and interesting sketch to the public.

J.P.W.

The Medico-Military Arrangements of the Japanese Army in the Field. By Surgeon Colonel W. Taylor, M. D., Principal Medical Officer, South Eastern District, Aldershot Military Society, 1895. Gale and Polden, Publishers, London, England.

Admiral Fremantle, R. N., in commenting upon the Japan-China war writes that the principal lessons to be learned from that remarkable conflict is ethical. "It lies deep in the traditions and temperaments of the two nations. The warlike, go-ahead, Japanese have won all along the line, while the peaceable, conservative, Chinese have disastrously failed to make any respectable defence of their hearths and homes." But to us the most important military lesson to be learned from that war and one that we of a boasted higher civilization cannot afford to neglect, is the value of organization and preparation, it was these and not individual physical superiority which enabled forty million *Wojen* (dwarfs) to overcome a nation ten times more numerous.

Hardly a quarter of a century ago when the Japanese finally concluded to adopt the western civilization they appointed a commission to visit all nations and learn what was best therein. In this pilgrimage it was found that France had the best army and Great Britain the best navy while our own country possessed the best system of education, and these are the models upon which Japan has formed her public schools, her army and her navy.

The admirable organization of the Japanese army (now somewhat Germanized), extends itself to the sanitary department, for though their national commission found no religion they could recommend for adoption yet humanity seems to meet with recognition at the hands of this people; or can it be possible they realized that, humanity aside, a properly organized sanitary department is absolutely essential to the effectiveness of an army? Whatever the reason certain it is that in organization, personnel, material, and efficiency, as we learn from the admirable address of Surgeon-Colonel W. Taylor, British Army, there seems little left to be desired.

Our author says that among other things we fail to realize regarding this nation is the fact "that Japan had physicians and surgeons of the highest standing, many of whom had taken first honors in American and European

schools, and some of them were and are pioneers in bacteriology and other branches of scientific research." In view of this fact it is not surprising that examination into the details of organization of their sanitary department shows them to be abreast of the latest advances in the French Army, which may to-day be regarded as the most perfect.

Beginning with the regimental medical organization with a personnel of 4 medical officers; 3 non-commissioned officers, attendants; 12 privates, attendants, and 48 company bearers; and material consisting of 6 panniers and 12 hand-litters carried upon the backs of 4 horses, the organization spreads out to the rear into the divisional bearer column, consisting of the headquarters and two bearer companies.

The personnel of the headquarters embraces 1 chief medical officer, 7 medical officers, 1 apothecary officer, 1 commissary officer, 3 pharmacists, 13 non-commissioned officers, attendants, (clerks and chief clerk), 26 privates, attendants, 1 non-commissioned officer, transport, 3 privates, transport, (1 horse shoer), 36 carriers, transport, 2 servants, and 2 grooms, (49 horses).

To each bearer column headquarters there is detailed a captain of the line, who serves for the day or week, and whose duties are disciplinary.

The personnel of each bearer company numbers 1 captain, 9 under-officers, 145 privates, (1 trumpeter, 1 tailor, 1 shoe maker), and 1 groom, divided into two platoons each of three sections. The duty of the bearer column is to transport the wounded from the regimental collecting stations, to which point they are brought by the company bearers, to the dressing stations established by it, whence they are transferred to the field hospitals (one for each division).

The material consists of:

Four medical and surgical panniers, 8 reserve panniers, 96 hand litters and 2 tents, together with reserve clothing, provisions, cooking utensils, etc. All requiring for transport 36 horses. The dressing stations are divided into three sections known respectively as the receiving, operating, and dressing section, and the most detailed instructions are given in the regulations for their location, management, and movement.

The personnel of the field hospital includes:

One chief medical officer, 5 medical officers, 1 apothecary officer, 1 commissary officer, 6 chief attendants, 6 attendants, 3 pharmacists, 34 orderlies, 1 mechanic, 2 clerks, 6 privates, (clerk etc.), 1 non-commissioned officer, transport, 3 privates, transport, 38 porters, 6 servants, and 2 grooms. The material consists of 4 medical and surgical panniers, 8 reserve panniers, 4 tents, together with clothing, food, cooking utensils, treasure-chest, and officers' baggage, all transported upon the backs of 38 horses.

The field hospital consists of two divisions each capable of acting independently, and the regulations also contain the most minute details regarding its function, location, movement, etc.

The departments of the field hospital are: offices, wards, operating room, dispensary, store-rooms, kitchen, bath-room, latrines, recreation-rooms, mortuary, etc.

From the field hospital the wounded are turned over to the care of the medical department on the lines of communication, by the transport staff, and find their way back to the more or less permanent hospitals, convalescent camps, etc., at the base of operations, from whence, if necessary, they are sent home to be distributed to the hospitals throughout the country.

Each stage of the wounded man's journey, from the firing line until he

finally reaches home, is provided for by the most careful and detailed organization, nothing is left to chance so far as human intelligence can anticipate possibilities.

In addition to the foregoing each division has a reserve medical staff of 7 medical officers, 1 commissary officer, 1 apothecary officer, 3 pharmacists, 14 chief attendants, 40 attendants, 8 servants and 1 groom. It also has a reserve medical store under charge of 2 officers, 5 non-commissioned officers, and 10 privates.

The entire sanitary work of the division is under the immediate direction and control of the Division Chief Medical Officer, who is assisted by one apothecary officer and two under officers. Each army also has its own Medical Staff, and at General Headquarters there is a field medical commander (Surgeon General) who is the chief of the medical service of all the armies.

It is most interesting to hear from an eye-witness of the practical results which have been obtained by this organization in caring for the sick and wounded, and its inestimable value to the fighting machine in keeping its front unhampered by invalids.

It has become quite the fashion to prate about the terrific casualties of future wars, in fact to predict that because of the destructiveness of modern ordnance war will be rendered too frightful to be endured, and therefore there will be no more wars. In all this the prophets have failed to reckon with the man rather than the gun, and they have forgotten the fact so well stated by Forbes, "that the more modern battles of Europe, in which great numbers of men have been engaged, battles in which were used rifled cannon and small arms, have afforded greatly less percentages of casualties than those of earlier battles in which smooth bore cannon and muskets were the sole weapons of fire."

While the Japan-China war can in no sense be regarded as typical of what a conflict between two warlike and modern armed nations will be, yet it teaches certain lessons of universal application some which are of especial value to the military sanitarian. Our author refers to numerous instances of the work of the Sanitary Corps which fell under his personal observation; he says "at Port Arthur there were opportunities of seeing how every part of the medical machine worked * * * in the fighting line everything was done that could possibly have been done. Lives were saved on the spot where the men fell by the prompt application of the tourniquet, and large arteries even were ligatured under heavy fire. I saw two men brought back to the dressing station from the line of attack on one of the forts, both of whose lives were saved by ligature, one of the femoral another of the axillary artery, the tallies* in each case gave the particulars of what had been done under difficulties, but with every care, and asked for immedate attention to the wounds which had been protected by the first dressing. The wounded were removed from the field without any delay just as quickly and quietly as they always were on the bi-weekly parades of the bearer columns in time of peace. If regiments were engaged far ahead. the regimental bearers did the work until the bearer companies came up when they again took their places in the ranks. There was no loss of time, the medical officers and attendants were everywhere." * * * And thus he goes on describing so graphically what he actually saw, no wounded left for hours unattended, no waiting for the battle to

* Diagnosis tags.

cease. I quote again: "At Wei-Hai-Wei on the 30th of January the steadiness which results from drill or practice was demonstated in a splendid manner.

"A regiment which in forgetfulness of the warning of the marshal commanding in his orders of the night before, that troops were not to be exposed on the beach of the harbor for fear of drawing upon them the fire of the Chinese ships still there, and in the excitement of pursuit of thousands of the enemy in flight, advanced across the flat sandy beach for some distance and suddenly found itself under fire from the quick firing and machine guns of three Chinese ships and from torpedo boats at a distance ranging from 200 to 600 yards. * * * The regiment which was in line was taken in the flank, and at the first discharge over 80 men were down and the saddles of the two mounted officers were empty. It was evident that the regiment was in danger of being soon annihilated, but some one had his wits about him for in a few seconds every man was on his face and soon were all crawling or making rushes, while stooping, towards a ravine to their left. There the regiment reformed, but even while the men were creeping away we saw suddenly the medical officers and stretchers spread over the field at some distance from one another. They walked in that storm of bullets as quietly as if on the parade ground at Tokio * * * In twenty minutes there was not a dead or wounded Japanese soldier on the beach."

What a contrast this actual experience is with the picture of future battles recently drawn by a distinguished writer, who says: "The victor will hasten away * * * leaving the wounded of both sides to be dealt with as may be possible by such surgeons as he can afford * * * and to the ministrations of cosmopolitan amature philanthropists of the Red Cross and kindred organizations. For there will be no more military bearer companies, etc."

A wonderful people the Japanese, intelligent, loyal, brave, and in nothing are these qualities better illustrated than in the organization and practical working of their military sanitary department, the whole army, indeed the whole country, sympathized with the work, and with such support success was assured.

JOHN VAN R. HOFF,
Major, Surgeon, U. S. Army.

Our Military Horses, by Veterinary Lieutenant-Colonel H. Thomson, District Veterinary Officer, Aldershot.

This is the title of a lecture, published in pamphlet form, delivered by the author before The Aldershot Military Society, December 10th, 1895, and embraces in its scope, the selection, reception, training, and stable management, of Cavalry and Royal Horse Artillery remounts.

Much of the matter embraced in this useful little pamphlet, is not new to American officers; but a number of points touched upon, are interesting. in view of the dissimilar customs and opinions, held in this country by military men.

As the English cavalry is classified as regards weight of horses and their riders, into Light, Medium, and Heavy, it is to be noted that the purchase of remounts is thereby rendered more complex,—the heights varying from 15 hands to $15\frac{3}{10}$. But as such horses are purchased under the English system as three or four-year-olds, there is abundant opportunity to develop. Specifications for cavalry and light artillery remounts, purchased by the United States Quartermaster's Department, have recently specified a height of $15\frac{1}{4}$ to 16 hands for the cavalry; and $15\frac{1}{2}$ to 16 hands for the light artillery,—the

age, in both cases being from four to seven years. The Army Book for the British Empire (1893), specifies heights and ages almost identical with our own.

While there is in our own service, no *Queen's Regulations*, or similar instructions for the training of remounts, most progressive troop and light-battery commanders go about it in much the same way as recommended by Lieutenant-Colonel Thomson. In fact, with the abandonment of our recruiting depots, our remounts and our recruits are treated in much the same manner. The animals, under a selected officer, are first carefully watched, and fed, to anticipate diseases due to climatic changes and other causes; handled daily on all parts of the body to accustom them to the bearings of loads and the proximity of their future master,—man; made to stand in stalls with old horses; ridden quietly about at first, by selected horsemen; and by the bending lessons, throwing, and elementary movements of the "School of the Trooper," made to understand their complete subservience to the will of the rider, manifested through the legs or bridle-hand.

The writer complains of the tendency in the English service to rush remounts through preparatory training in order to make them available for service in the ranks,—the young (three-year-olds) being too young and undeveloped to stand the work of five-year-olds. He recommends, as an antidote for this evil, the adoption of the fifth (depot)-squadron system in vogue in continental armies, which squadron would be the training school for the recruits and remounts, previous to assignment to regular duty.

Although, in our own service, there is probably too little time devoted to the elementary education of remounts (the Germans give one year's training after the remounts come from the remount-depots), the fact that our horses are purchased over four years of age, enables them to almost immediately stand the strain of active service without breaking down. At the same time, horses purchased at that age are not so subservient to training, and bad habits, once fixed, are difficult to eradicate. The utilization of one or both of the "skeleton troops" in our cavalry regiments for the training of recruits and remounts, would be along the lines recommended by Colonel Thomson.

In his remarks upon the construction of stables, the writer prefers a hard surface, such as concrete, for the floors,—impervious to moisture. This is also the preference of Fitzwygram. Few cavalry stables in the United States have floors, other than earthen. At Fort Myer, where two modern stables have floors of concrete, criticism is made by troop commanders, that although the smooth surface is conducive to cleanliness, the horses fall frequently, in spite of corrugations; the hoofs are pounded injuriously on the hard surface; and that this, coupled with the almost total absence of moisture, makes the hoof brittle and inelastic. Two stables, constructed later, have clay floors.

A reduction of the British cavalry equipment (marching order) is also recommended,—the total weight varying from 19 to 22 stone (266 to 308 pounds). The equipment varies from 110 to 122 pounds; while the United States equipment averages only 90 pounds.

The writer declares the British forage allowance of 10 pounds of oats and 12 of hay, insufficient for the horses of the heavy cavalry, and artillery, and when we compare it to our own allowance, it seems, indeed, very small. Colonel Thomson recommends that unless the forage ration be increased, the oats be increased to 12 pounds at the expense of a decrease in the hay

allowance to 9 pounds. He also recommends the use of oat-crushers in connection with chaff-cutters,—something hitherto untried in our army stables.

To American officers, the writer's argument in favor of clipping army horses, will appear novel, to say the least. It is stated, that after clipping, the horse, by a total absence of profuse sweating, saves the equivalent nutrition of a feed of oats; that clipping, by increasing the rapidity of drying, decreases the risk of chills; and finally, that the men are saved an immense amount of grooming.

Our mounted officers will hardly agree with these views. In our changeable climate (and the English climate is not the mildest in the world), we would prefer, except, perhaps, in the extreme south, to risk colds, with our animals clothed in their natural coats; and would trust, as we now do, to proper exercise and blanketing to avoid too sudden cooling off, rather than to deprive "man's best friend" of that which nature has evidently provided for protection, and which, by natural laws, is shed or increased, as necessity requires.

C. D. RHODES,
2nd Lieutenant, 6th Cavalry.

Field Exercises, Supplementary Report of Brigadier General James W. Forsyth, 1895.

General Forsyth has done the army at large a great service and given his officers an interesting experience in carrying on the work initiated by General Miles and carried to the highest point it has reached in our army by General Merritt, viz: the execution of summer maneuvers with such troops of the three armies as could be assembled. Any movement which tends to give the army *practical* experience in line with its preparation for its legitimate rôle in war is of immense benefit, and no class of officers appreciate this more than the artillery officers, who, with the exception of those serving in the light batteries, have as yet no opportunity to perfect themselves practically in their rôle to *hit* with the weapon they are to use in war.

The troops which took part in these exercises were seven companies of the 1st Infantry, two troops of the 4th Cavalry and light battery D of the 5th Artillery.

The general situation assumed an infantry brigade holding Monterey, an infantry brigade of the enemy being encamped about 10 miles south of Monterey, moving forward to attack that place.

As preliminary instruction written solutions of the following problems were required:

1. Monterey to be held: outposts established.
2. Army retreating up the coast: rear guard compelled to defend itself at Monterey.
3. Army in bivouac at Pacific Grove: temporary outposts established.

Twelve exercises were carried out practically, involving reconnaissance by small and by strong patrols, special reconnoissance and contact with the enemy, attack of a position, combat of advance guards, outposts, escort of convoys and combat between advance guard and rear guard.

The comments (which were made after each exercise) are replete with common sense and useful information, even for those who study the maneuvers at a distance, and the pleasant spirit in which the criticisims were made must have inspired all with confidence in the good judgment as well as the sympathy and co-operation of the commanding general.

"Too much nervous haste to accomplish results is characteristic of all our efforts. This is easily explained on the score of enthusiasm and excitement, influences which the Commanding General freely acknowledges he is, himself, not free from."

The preliminary address by General Forsyth and the re-issuing of the circular issued by General Merritt in the camp at Chilocco Creek, I. T., in 1889, giving a brief summary of the principles of tactics to be employed, show how necessary is a preliminary study of minor tactics by all the officers in a practical way, so as to render such addresses and circulars unnecessary. These principles should be second nature with officers before they take actual command of troops in the field, and this can only be accomplished (1) by a simple study of the text-book, (2) by the solution of practical problems in the open (as well as written solutions indoors in bad weather) and (3) by the actual execution with the troops *you* are to command, the others being imaginary; in this way alone can *all* the time in the field be devoted to actually commanding the troops to the best advantage.

J. P. W.

Militärisches, founded by von Prollins. Zuckschwerdt and Company, Leipzig. 4.75 M. a quarter.

A new monthly military magazine under this title has made its appearance, in the form of a neat, red-covered pamphlet of eighty pages a number.

This new periodical aims at attaining a *general* and *international* character, and certainly the variety exhibited in the articles of this its first number is sufficient to satisfy its ambition in this direction. Its contents comprise articles on *Count von Zieten*, *Points and Patrols of Divisional Cavalry and Cavalry Divisions*, *Advanced Positions*, *Comparison of the Homeric and the present Military Sanitary Measures*, *the Service of Information in War*, *and the Italian-Abyssinian War*.

The numbers which have thus far appeared show that this magazine bids fair to be exceedingly interesting and valuable, particularly in the domain of minor tactics and its applications in military history.

J. P. W.

Monde Militaire (Le).—Paris: 76 Rue de Seine. Fortnightly. 6 francs a Year.

A new publication of but four or five pages a number, giving a list of all the military publications issued from time to time in France and abroad. Each number also contains a short essay discussing, for example, the drill and other regulations of the French army, a tactical problem, or the changes going on and important questions arising in foreign armies. It begins modestly, but it will evidently make itself useful. The publishers' names attached to the works mentioned would add much to its usefulness.

J. P. W.

INDEX TO CURRENT ARTILLERY LITERATURE.

PERIODICALS CITED.

Abbreviations employed in index are added here in brackets.

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* Other reprints of articles of the *Journal* not heretofore noted are: Captain Ingalls' in *Revue de l'Armée Belge;* Lieutenant Harmon's (Crozier carriage) in *Revue de l'Armée Belge;* Lieutenant Squier's in *Memorial de l'Artillerie de la Marine*, *Physical Review*, *Indian Engineering* (Calcutta), *Revue d'Artillerie*, *Mittheilungen über Gegenstände des Artillerie und Genie-Wesens*, *Scientific American Supplement*, *Proceeding Naval Institute*, *Electrical World*, *Artillerie Tidskrift*, *Revista Cientifico* (Barcelona), *London Engineering*, *Archiv für die Artillerie und Ingenieur Offiziere*, *Cosmopolitan*, *Army and Navy Gazette*, *etc.* General Abbott's in *Revue l'Armée Belge*, and in *Rivista di Artighieria é Genio*, *etc.* Lieutenant Weaver's in *Revue Maritime et Coloniale*, *etc.;* Mr. Benét's in *London Engineer*, *etc.;* Lieutenant Parkhurst's in *Electrical Review*, *etc.;* Colonel Sanger's in *Revista Militar*, (Lisbon); Captain Schenck's in *Proceedings Royal Artillery Institution;* Captain Zinn's in *Génie Militaire*, Professor Greenhill's in *Rivtsta Militar* (Lisbon). Captain Ingalls' latest work on ballistics was reprinted entire in *Memorial de Artilleria* (*Madrid*).

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MAY–JUNE.

Vol. V. No. 3. Whole No. 20.

1896.

JOURNAL

OF THE

UNITED STATES ARTILLERY

PUBLISHED BY AUTHORITY OF THE

STAFF OF THE ARTILLERY SCHOOL.

ARTILLERY SCHOOL PRESS.

FORT MONROE, VIRGINIA.

ENTERED AT THE POST OFFICE AT FORTRESS MONROE, VA., AS SECOND-CLASS MATTER.

UNITED STATES ARTILLERY SCHOOL.

FORT MONROE, VIRGINIA.

The *Journal of the U. S. Artillery* is published at the Artillery School as a bi-monthly, by authority of the Staff of the School.

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Subscription $2.50
For countries in the postal union $3.00
Single numbers $0.50

Subscriptions in all cases date from January 1st; and remittances should be sent to the editor at Fort Monroe, Virginia.

AGENTS.

NEW YORK—*Dyrsen & Pfeiffer*, successors to
F. W. Christern, 254 5th Avenue.
LONDON—*B. F. Stevens*, 4 Trafalgar Square.

JOURNAL

OF THE

UNITED STATES ARTILLERY.

VOL. V. No. 3. MAY—JUNE, 1896. WHOLE No. 20.

VERTICAL FIRE IN SEA-COAST BATTERIES.

As has been pertinently remarked by Captain Ingalls, there is so wide a difference between the conditions attending the firing of a single mortar and those affecting an equal number of shots from a group, each mounted on its own separate carriage and platform, that records of actual practice are needful before a mathematical discussion of group firing can be really satisfactory. Such records were obtained for the first time last spring. The firing was conducted at the completed service mortar battery at Sandy Hook by Captain Heath, Commanding the Proving Ground, and every attention was given to ensure accuracy, both in the practice and in the records. These highly important data form the subject of this paper, which may be regarded as a continuation of one that appeared in Volume II of the ARTILLERY JOURNAL, with its addenda on page 45 of Volume III.

The firing was had under two programmes: (1) Volleys from single pits each containing four 12-inch mortars, designed to prove the new pieces and carriages in their final positions; and (2) Volleys from the entire battery of sixteen mortars fired under service conditions. The latter firing occurred on April 11, 1895, in the presence of many officers stationed in New York Harbor and vicinity.

PROOF FIRING, SINGLE PIT VOLLEYS.

As proof firing requires full service charges, and as the ngest land range at Sandy Hook is only 6000 yards, most of e practice was had toward the ocean, but two of the volleys re directed down the beach where the shell fell on land. The se used in the triangulations is five miles long; and as a preinary shot was always fired from a neighboring pit, with the me charge and pointing as the volley, to enable the observers point their telescopes with precision, no trouble was found in cating the columns of spray accurately.

In discussing this firing, the width of the 50 per cent. zones of lateral and longitudinal dispersion has been computed by multiplying by 1.69 the corresponding rectangular distance of each splash from the coordinate planes intersecting at the central point of impact of all four shell. The mortars being located at the angles of a square 20 feet on a side, this method refers the impacts to the center of the pit as an origin, and the figures therefore indicate single pit dispersion and not that from the planes of individual mortars. This method is necessary since the particular mortar from which each separate projectile proceeded could not be determined.

The following table exhibits this practice. Where volleys were fired with identical charges and elevations they are grouped, and the means given, as a check on the precision attained. In the four volleys fired from the southwest pit a variation of two pounds was made in some of the charges, and this has been corrected by the addition of 100 yards to the observed ranges of the smaller charges:

Mortar Pit.	Number of shots.	Elevation, degrees.	Shell, pounds.	Charge, pounds.	Range, yards.	50 per cent. zones in yards. Lateral dispersion.	Longitudinal dispersion.	25 per cent. probable rectangle, square yards.	Remarks.
				Shell falling in water.					
North west.	3	45	635	74	9359	55.8	15.2	848	One shell lost.
South east.	4	45	802	60	6880	13.5	108.2	1461	
South east.	4	45	802	70	8107	6.8	167.3	1138	
South west.	4	60	806	69	6512	45.6	30.4	1386	
North west.	3	45	635	78	9760	57.0	135.0	7774	One shell lost.
" "	3	45	635	78	9760	32.0	51.0	1627	One shell lost.
" "	4	45	635	78	9792	51.0	57.0	2913	
Means.	.	.	. .	.	9770	47.0	81.0	4105	
South east.	4	45	802	76	8783	24.0	167.0	3965	
" "	4	45	806	76	8816	32.0	74.0	2388	
" "	3	45	806	76	8785	12.0	110.0	1296	One shell lost.
Means.	.	.	. .	.	8795	23.0	117.0	2550	.
South west.	4	60	806	74	7022	32.0	56.0	1791	
" "	4	60	806	74	7115	13.0	58.0	776	
" "	4	60	806	74	7201	12.0	15.0	179	
Means.	.	.	. .	.	7113	19.0	43.0	915	
				Shell falling on beach.					
South west.	4	60	802	29	3070	13.5	13.5	172	
South west.	3	60	806	62	6196	11.8	20.3	240	One shell lost.

VOLLEYS BY BATTERY, UNDER SERVICE CONDITIONS.

Two full battery volleys were fired down the beach, one at a range of about 3000 yards and the other at about 6000 yards. The battery was fully equipped for service, with magazines and galleries lighted by electricity and with the firing wires in position. Ignition was effected with a Laflin and Rand magneto electric machine No. 4, placed at the regular station at the end of the long gallery. As will be done in actual service, the four mortars in each pit were fired simultaneously, with an interval of two or three seconds between pits, to lessen the concussion in the galleries. All the pieces were pointed in parallel planes by their azimuth circles, and the charges and elevations were identical, the latter being 60 degrees. For the shorter range the charge was 29 pounds of black hexagonal powder, and for the longer range 60 pounds of brown prismatic powder. The shell were all brought to the same weight, 815 pounds, and they were marked so that the mortar from which they had been fired would be known.

At the 3000 yard volley, one of the mortars in the north east pit was not ready and therefore was not fired. All the shell were recovered and identified.

At the 6000 yard volley all the mortars were fired; but as the shell fell upon a low sandy beach where they penetrated ten feet or more, it was impossible to recover six of them for identification, the water flowing into the holes faster than it could be pumped out. One shell could not be found, two falling, as was believed, in the same hole.

The accompanying tables afford the data for a close study of these important observations. They are based on the accurate survey of the ground by Captain Heath and his assistants, to whom credit is due for excellent good judgment in conducting the firing and for indefatigable perseverance under many difficulties in recovering the projectiles for identification.

The tables have been constructed to permit the deviations to be studied both from individual mortars and from the central point of the entire group of sixteen mortars, which it should be remembered is not at the central point of the battery exactly. It is the center of the circle 300 feet in diameter which includes all of the sixteen pieces.

These observations are instructive from two points of view: (1) as ballistic data, and (2) as throwing light upon certain practical problems in the use of mortars in coast defense. Each will be considered in turn.

The Three Thousand Yard Volley.

Number of mortar.	Mortar pit.	Range in yards from: Mortar.	Difference.	Range in yards from: Middle of entire group.	Difference.	Deviation in yards from: Plane of fire through mortar.	Difference.	Deviation in yards from: Parallel plane at middle of entire group.	Difference.
14	N.E.	3022	26	3030	33	279	20	235	27
13	"	3017	21	3022	25	265	6	215	47
30	"	Mortar not fired.							
18	"	3013	17	3015	18	246	14	205	57
58	N.W.	3007	11	2978	19	266	7	237	25
67	"	2984	12	2953	44	255	4	220	42
66	"	3014	18	2977	20	248	11	216	46
65	"	3040	44	3005	8	282	23	256	6
15	S. E.	2960	36	2999	2	267	8	299	37
19	"	2985	11	3021	24	272	13	298	36
64	"	2924	72	2954	43	239	20	268	6
20	"	2979	17	3012	15	245	14	280	18
21	S. W.	3019	23	3021	24	259	0	307	45
22	"	3016	20	3015	18	244	15	285	23
70	"	2997	1	2990	7	252	7	296	34
17	"	2969	27	2965	32	263	4	313	51
Means		2996	23.7	2997	22.1	259	11.1	262	33.3

The Six Thousand Yard Volley.

Number of mortar.	Mortar pit.	Range in yards from: Mortar.	Difference.	Range in yards from: Middle of entire group.	Difference.	Deviation in yards from: Plane of fire through mortar.	Difference.	Deviation in yards from: Parallel plane at middle of entire group.	Difference.
14	N. E.	5656	8	5653	104	506	61	462	20
13	"	5764	0	5757	0	448	3	398	44
30	"	5814	50	5801	44	405	40	359	83
18	"	5791	27	5782	25	434	11	394	48
65	N.W.	5780	16	5739	18	499	54	482	40
64	S. E.	5755	9	5790	33	423	22	444	2
15	"	5843	79	5888	131	422	23	444	2
70	S. W.	5779	15	5782	25	427	18	471	29
17	"	5697	67	5704	53	442	3	492	50
?	?			5663	94			429	13
?	?			5746	11			465	23
?	?			5756	1			476	34
?	?			5720	37			427	15
?	?			5730	27			420	22
?	?			5850	93			459	17
?	?			Shell not recovered.					
Means		5764	30.1	5757	46.4	445	26.1	442	29.5

Ballistic results.—In the paper on vertical fire printed in the ARTILLERY JOURNAL in 1893, such data were discussed as I had been able to collect respecting practice with single sea-coast mortars. Since that date firing has been conducted at Sandy Hook (in December 1893 and April 1894) to compare the cast-iron steel hooped mortar with the all steel pattern, and in April and May 1895 to test the accuracy of the latter; the figures are given here to bring that record up to date. The formula referred to in the table is the following, in which A denotes the area in square yards of the 25 per cent. probable rectangle, and R the range in yards.

$$A = 0.00001\, R^2.$$

Kind of mortar.	Wind, miles per hour.	Number of shots.	Elevation, degrees.	Weight of shell, pounds.	Charge of powder, pounds.	Mean range in yards.	50 per cent. zones, in yards. Lateral dispersion.	50 per cent. zones, in yards. Longitudinal dispersion.	25 per cent. probable rectangle, sq. yds. Observed.	25 per cent. probable rectangle, sq. yds. By formula.
Hooped . .	calm	5	60	1000	27	2353	3.2	6.0	19	58
Steel . . .	10-18	5	60	1000	31	2432	14.2	31.1	441	62
Hooped . .	calm	5	60	800	77	7646	9.7	37.2	362	610
Hooped . .	4	5	60	1014	30	2496	6.9	15.6	107	62
Steel . . .	4	5	60	1014	32	2464	15.8	3.9	62	61
Hooped . .	10	5	60	811	77	7434	19.2	41.9	805	553
Steel . . .	10	5	60	811	83	7346	28.1	79.1	222	540
Steel . . .		5	45	800	106	10791	47.0	94.2	4434	1165
Steel . . .		5	50	800	106	10718	39.1	40.7	1590	1149
Steel . . .		5	55	800	106	10214	6.5	63.7	413	1043
Steel . . .		5	60	800	106	9285	24.2	60.9	1472	862
Steel . . .		5	45	800	109	11859	19.3	14.9	288	1406
Steel . . .		5	50	800	109	11641	20.0	72.9	1458	1355
Steel . . .		5	55	800	109	11039	13.4	76.7	1034	1219
Steel . . .		5	60	800	109	9861	16.8	96.0	1610	972
Sums							283.4	734.8	14317	11117

Bearing in mind that the means in this table are based on only five shots, which are not enough to give a very close determination, the general accordance between the measured and computed probable rectangles over so wide a variation in range is certainly striking, and strongly tends to confirm the conclusions reached in 1893, viz: "While great accuracy is not claimed, * * the discussion shows that precision of fire (measured by the reciprocals of the 25 per cent. probable rectangles) is inversely proportional to the square of the range, or thereabouts." It

remains to see what light the recent volley firing throws on this point.

The only data where the observed dispersion of the projectiles is referred to the individual mortar from which each was fired, and the plane of the trajectory passing through it, are the following, which are derived from the two volley tables given above.

Number of shots.	Range in yds.	50 per cent. zones in yards.		25 per cent. probable rectangles in square yards.	
		Lateral.	Longitudinal.	Observed.	By formula.
15	2996	18.7	40.0	750	89.8
9	5697	44.1	50.9	2244	324.7

It must not be forgotten that every mortar mounted for service has its own "personal equation," and that this will depend not only on its own perfection of manufacture but also very largely on the accuracy of graduation of the azimuth circle, the correct placing of the zero in the meridian, the care given to accurately level the platform and especially the axis of the trunnions, etc., etc. It is therefore apparent that the numerical coefficient of a formula derived from practice with single pieces must be too small when the firing of different mortars is combined in a volley. All that should be expected is that the law of the squares should be confirmed, and that this is confirmed by these data is shown by the following figures:

For the shorter range, $2996^2 \times 2244 = 20\ 142\ 200\ 000$.

For the longer range, $5697^2 \times 750 = 24\ 341\ 900\ 000$.

Accepting then the dictum that in single mortar practice, or in volley practice when the deviations of each projectile are referred to its own piece and to the plane of its own trajectory, the 25 per cent. probable rectangle is a function of the square of the range, the coefficient of the formula applicable to the Sandy Hook battery can be easily computed from the above table. Thus

$$\text{For the shorter range } \frac{750}{89.8} = 8.36.$$

$$\text{For the longer range } \frac{2244}{324.7} = 6.91.$$

Adopting 7 or 8 as a sufficiently close approximation to the numerical value of this coefficient the Sandy Hook battery formula becomes

$$A = 0.00007\ R^2 \text{ or } A = 0.00008\ R^2.$$

Comparing this with the expression for single mortar practice, viz: $A = 0.00001\ R^2$, it appears that the area of the 25 per cent. probable rectangle for a single mount is only increased seven or eight times when the firing is done from sixteen different mortars, carriages and platforms, a fact which certainly speaks well for the care exercised by both the Ordnance and Engineer Departments in equipping this battery.

The next matter for consideration, and this is the important practical question, is the total distribution to be expected when the firing is done from the entire battery, and is estimated from the middle point of the group and from the vertical plane passing through this point and parallel to the several planes of the trajectories. A similar discussion might be undertaken for each pit referred to its middle point, but it would possess comparatively little interest and will not be attempted.

It is to be noted that the deviations caused by separating the mortars when the points of impact are referred to a common system of coordinate axes, is relatively less as the range increases. Moreover every deviation from the plane of fire increases the dispersion when referred to that plane, while deviations toward an intermediate plane of reference may increase the apparent accuracy. For these and other reasons it may be inferred that when referred to the central plane the 25 per cent. probable rectangles will vary with a lower power of the range than the square.

The data available for this investigation are the following, derived from the two volley tables given above. Since the engineer requirements for magazine cover, etc., compel the facing of the four pits at the corners of a rectangle, not a square, the relative positions of the mortars will depend upon the angle which the plane of fire makes with the axis of the long gallery. When firing parallel to this axis the dispersion in range will have its maximum value; and the dispersion laterally, its minimum value. With the plane of fire at right angles to this axis, the reverse will hold in both cases. For the 3000 yard volley the actual angle between these lines was 37 degrees, and for the 6000 yard volley 23 degrees. The figures therefore correspond to fair average conditions. As at the 6000 yard volley only nine of the shell were identified with the mortars from which they were fired, although all were accurately located, the results are discussed separately in the table. The elevations in every case were 60 degrees.

Number of shots.	Range in yds.	50 per cent. zones in yards.		25 per cent. probable rectangles in square yards.	
		Lateral.	Longitudinal.	Observed.	By formula, below.
15	2997	37.4	56.3	2101	2098
9	5764	53.2	79.6	4238	4035
15	5757	49.8	78.4	3909	4030

It is evident from an inspection of these figures that the 25 per cent. probable rectangle is proportional to the first power of the range rather than to its square, as in the case of single mortar firing referred to the actual plane of fire; and it remains to decide from the several values of the coefficient whether the accordance is sufficient to justify an assumption that this is the true function.

For the shorter range $\frac{2101}{2997} = 0.701$,
For the longer range $\frac{4238}{5764} = 0.735$,
For the longer range $\frac{3909}{5757} = 0.679$.

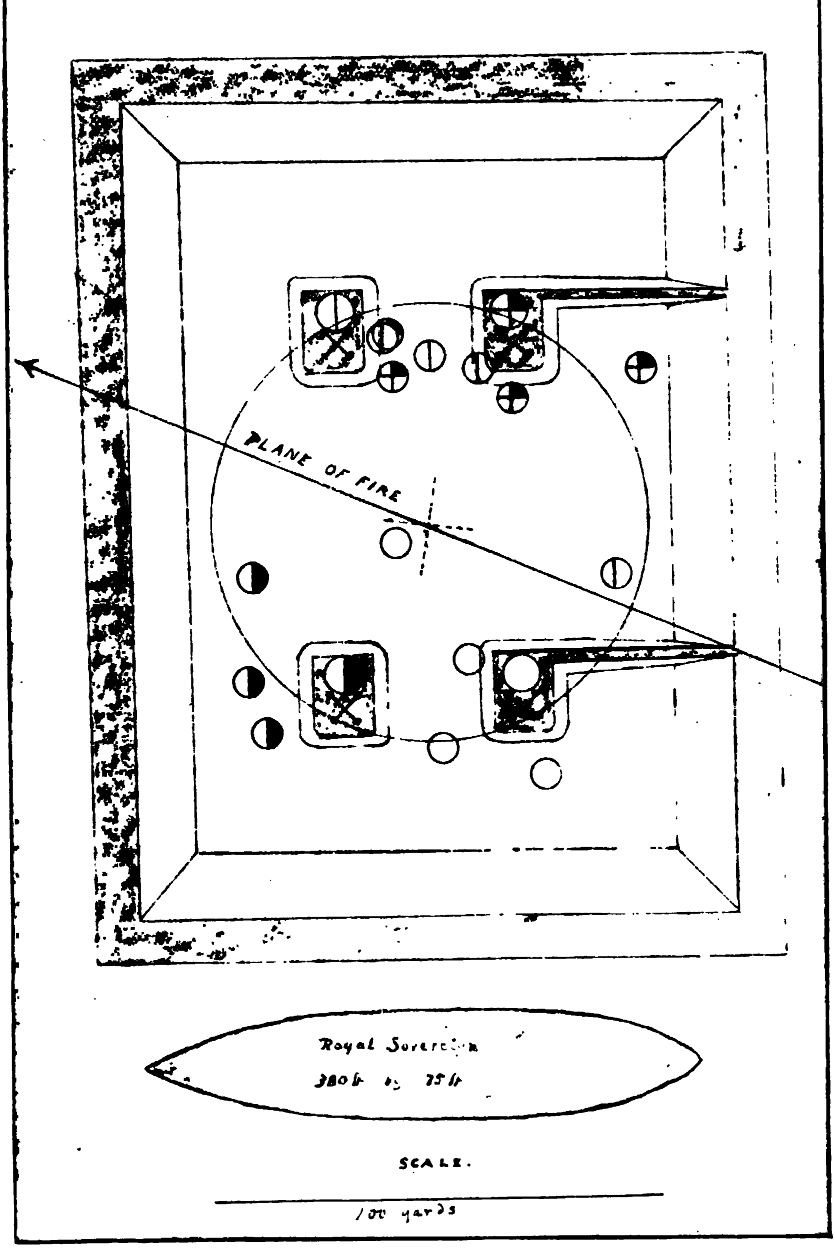
These values vary so little from each other that the assumption made seems proper; and also that, until further data are obtained, we may adopt 0.7 provisionally as the value of the coefficient; giving the following formula, used in the sixth column of the last table:

$$A = 0.7\ R.$$

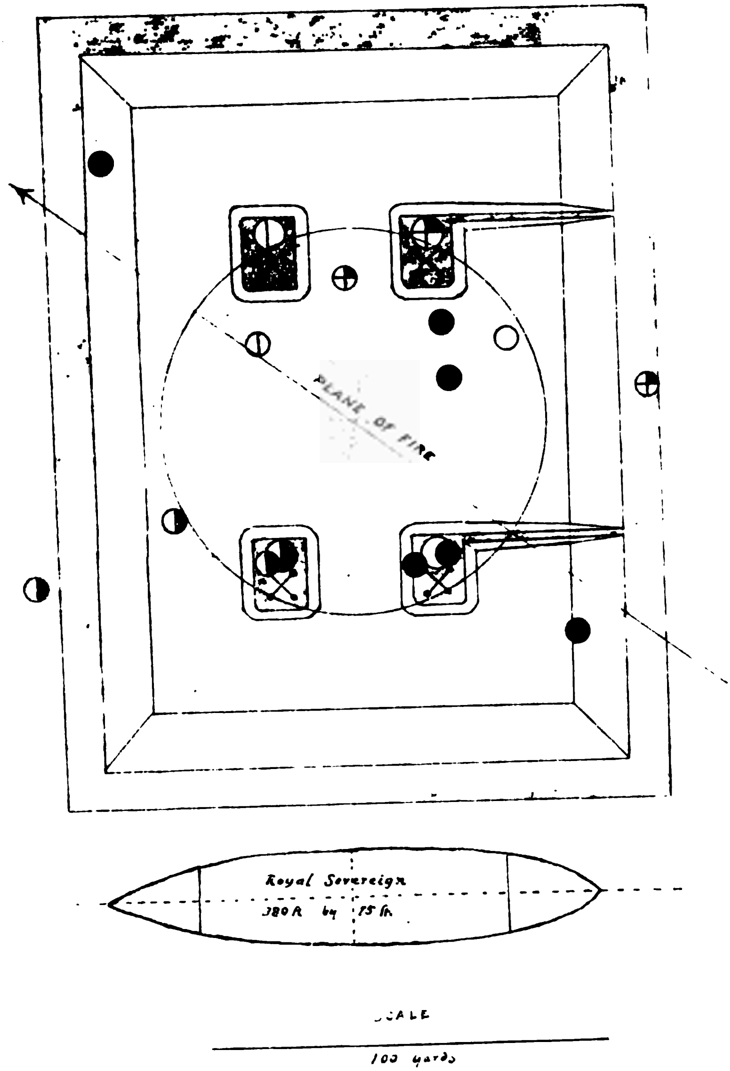
It may be urged that the existing data are insufficient to warrant definite mathematical conclusions on these several points, and I incline myself to this opinion; but it should be remembered that some estimate must be formed as to practical results to be expected in actual firing, and that conclusions based on a careful and rigid analysis of such materials as we have, are more to be trusted than the only alternative, bald guessing.

To sum up then, it appears from this important firing that the conclusion reached from earlier practice with single mortars and referred directly to the plane of fire, that the precision will vary inversely with the square of the range, is confirmed; but that when mortars are grouped as in the battery at Sandy Hook, the area included in the probable rectangle will be seven or eight times as large as when the practice is from a single piece. Also that when the service is by volley from the entire battery and is referred to a central plane of fire with ranges estimated from the middle point of the entire group, the precision will vary inversely with the first power of the range, and that the area of the 25 per cent. probable rectangle in square yards may be provisionally

3000 YARD TARGET



6000 YARD TARGET



assumed at seven-tenths of the range in yards. The actual dimensions of this rectangle at the 3000 yard range were about 35 yards in width by 55 yards in length; and at the 6000 yard range, 50 yards in width by 80 yards in length.

It remains to consider this firing from a less technical point of view.

Group Firing.—The new battery proved in every respect to be well adapted to its purpose. The smoke so far from accumulating in the galleries, as had been suggested would be the case, was blown entirely away by the rush of the air to fill the partial vacuum created in the pits by the simultaneous discharge of the four mortars. The supply, coming largely from the galleries, assures their perfect ventilation.

During the firing the galleries were occupied by several officers to note the effects of the concussion there. The sound was heavy and deep, and was prolonged by echoes and the rush of air, but it in no way would interfere with the artillery operations. None of the incandescent lamps were broken, nor were any extinguished, although this occasionally happened with ordinary lanterns. It seemed to be the general consensus of opinion that in service the firing should be restricted to simultaneous volleys from single pits, with intervals of two or three seconds between pits. Distributing the time of fall of a battery volley over a dozen seconds, will not tend to lessen the demoralizing effects on the enemy, while the concussion in the galleries will be materially reduced.

The projectiles in the air presented a novel and interesting appearance. As viewed from the battery, the first four shell moved steadily away preserving their relative positions as accurately as if at rest, and the successive discharges from the other pits followed in echelon at short intervals, until they all faded out of sight in the distance. Their arrival at the target was described by the watchmen there as no less startling than impressive.

Although the foregoing tables afford every facility for an analysis of the distribution of the impacts, they fail to impress their characteristic uniformity upon the mind; and I have therefore prepared the accompanying diagrams, to which attention is specially invited. All the points of fall are shown in their true relative positions; and to afford a convenient standard of comparison an outline of the battery itself is superposed in its true azimuth to the plane of fire, and with the middle point of its

sixteen mortars placed at the central point of impact of all the shell. Each pit and the projectiles from it have the same distinguishing symbol, so that the starting points can be easily determined.

It will be noted that at the 3000 yard range all the shell fell far within the area of the mound of the battery, which is 134 yards wide by 182 yards long; and at the 6000 yard range all but three fell within the area included by the counterscarp, which is 154 yards wide by 202 yards long. Evidently the anticipated resemblance to an old buck and ball target was realized.

To enable the probable effects upon a warship to be studied, the deck dimensions of the *Royal Sovereign* (built in 1892, length 380 feet, beam 75 feet) have been added to the diagrams. By tracing the lines on transparent linen and superposing them at different positions, an opinion as to the probable effect of the volley on the ship can be formed. The following summary of such a comparison is presented.

At the 3000 yard volley, the ship always lying at the central point of impact would have received 2 hits when head on; 3 hits when at right angles to the plane of fire; 2 hits in one position and 5 hits in the other when making an angle of 45 degrees with that plane. This indicates a general average of three hits, or 20 per cent of the shots fired. At one angle she would have received 7 hits, or 47 per cent of all fired. By my formula, derived from certain Japanese single mortar practice at an actual target at a range of about two miles, published in the ARTILLERY JOURNAL in 1893, the percentage of hits to be expected in this case is 25.

At the 6000 yards volley, the ship lying in the four positions above indicated would have received 1 hit, 2 hits, 2 hits, and 1 hit respectively giving a general average of 1.5 hits, or 10 per cent of the shots fired. At one angle she would have received 4 hits, or 27 per cent. My formula, which in this case predicts 10 hits, is the following, X representing the probable percentage of hits which would be received by a warship lying at a range of R miles, at the central point of impact.

$$X = \frac{100}{R^2 + 1}$$

The diagrams afford the means of extending this method of analysis to any desired extent. In brief it may be said that the distribution of the projectiles at both ranges was all that could be desired. The firing has certainly demonstrated that in one of these batteries sixteen mortars may be controlled by a single

officer in a most effective manner. While in single mortar practice the wandering increases very rapidly with the range, probably as its square, this system of grouping has materially reduced the ill effects, leaving only errors of this class dependent upon its first power to be overcome. So long as sportsmen recognize that one shot-gun is worth a dozen rifles in pigeon shooting, and so long as engineers appreciate the difficult conditions which hamper the artillerist in directing mortar practice against a ship of war, so long will batteries for vertical fire be constructed upon the principles whose soundness has been confirmed by this experimental firing.

Five of these batteries have already been constructed, and many others projected. As soon as the results of this firing became known all the details, including various matters of construction, the electric lighting, the arrangements for firing by electricity, the storage of ammunition and its most ready service (in a word every device for perfecting the arrangements) were carefully revised by the Board of Engineers and made the subject of an exhaustive report. It may be well in this connection to remark that the battery at Sandy Hook often conveys an erroneous impression upon visitors, because the high level of water in the sandy soil prevented any lowering of the pits and thus compelled an abnormal amount of enbankment. Of course whenever practicable excavation and embankment will be equalized, thus largely reducing cost to say nothing of favoing concealment.

In conclusion, I may be permitted to say that this type of battery was by no means developed by accident. The considerations which determined its form were partly artillery and partly engineer; and of the two, the former predominated. One does not expend 40,000 rounds of mortar ammunition, and spend months in the trenches studying every possible means of increasing the precision of vertical fire, without having it impressed on the mind that group control must be secured before perfection can be expected. Bringing many pieces into close juxtaposition where no variation in pointing is needful, is thus one essential condition of rapid and effective service against shipping. On the other hand the enormous amount of heavy ammunition required in a sea-coast battery (1700 tons to equip a sixteen-mortar battery with 200 rounds) introduces many troublesome engineer conditions. Moreover, long years have been required to secure ballistic data desirable for determining the proper grouping of the pits. At last, however, the type stands conpleted; and it is

my hope and belief that in the hands of artillery officers appreciating its theory and capabilities it will give a good account of itself in the next war.

By General HENRY L. ABBOT,
Colonel, Corps of Engineers, Retired.

EXPERIMENTAL DETERMINATION OF THE MOTION OF PROJECTILES INSIDE THE BORE OF A GUN WITH THE POLARIZING PHOTO-CHRONOGRAPH.

A Report of Progress to the Board of Ordnance and Fortification, U.S.A.,

BY

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In a previous paper* were described some preliminary experiments with the Polarizing Photo-Chronograph applied to the measurement of the velocity of projectiles outside the bore of a U.S. 3".2 breech-loading field rifle. The results of these experiments being submitted to the Board of Ordnance and Fortification, a chronograph built upon this principle, making use of polarized light, was authorized, and the construction of the same entrusted to our care.

Since the original experiments were more of the nature of a laboratory investigation than suited to the practical needs of the military service, it became our first purpose to perfect the details of the instrument by further experimentation, in order to avoid hastily assembling for the government an instrument which, when completed, would manifestly be capable of great improvements. Accordingly, under the direction of the Board of Ordnance and Fortification, the experiments to be described below were carried out at the U. S. Artillery School during the month of August, 1895.

The immediate objects of these experiments were two-fold. First, to perfect a practical chronograph upon this principle, suited to the needs of the military service, and second, to determine the adaptability of this instrument to the study of the motion of projectiles inside the bore of a gun.

* *Journal of the U. S. Artillery*, July, 1895.
Physical Review, July-August, 1895.

There was, at the outset, no reason to doubt that this chronograph could be employed as Noble's or Schultz's chronoscopes formerly have been, to determine interior velocities in cases where the gun might be mutilated by piercing holes along the bore at intervals, and inserting electric circuits to be interrupted by the projectile as it passes. Yet the usefulness of such a method is so insignificant compared with any plan which would enable interior velocities to be measured at any time, and in any gun, with almost as great ease as exterior velocities may now be obtained, that it became our purpose to search for such a method. Although the time as yet available for this work has been very limited, and the constant pressure of other duties prevented anything but a superficial examination of results, yet it is thought that sufficient success has been attained to warrant this early presentation of an account of the experiments thus far conducted. The observations themselves which are presented we deem of secondary importance compared with the method outlined, since they may easily be confirmed or disproved by future trials.

A superficial study of the history of interior ballistics cannot fail to convey the impression that the whole number of experiments giving reliable data is very small indeed, and those which are the most reliable have been worked over and over again, involving much labor which might profitably have been directed toward obtaining new experimental evidence. The elaborate preparations and great expense hitherto involved in carrying out such experiments have confined them to select ordnance committees backed by governmental aid, and are in a great measure responsible for the meager experimental data available.

In presenting the results of any physical experiments it is deemed of first importance to insist upon having the *original observations* given independent of any derived results, no matter how elementary the process of derivation. Unfortunately this principle has not been observed in many of the memoirs upon which we must depend, and furthermore the omission to state exactly from what experiment, or set of experiments, certain measurements are derived, greatly depreciates their value. In deciding upon a method of presentation of the results of this work, we were confronted at the outset with the generally accepted theories against which our superficial observations indicated some radical departures, and we had on this account some hesitancy in making any presentation at present, until further experiments could be conducted. It was our desire to test the well known formulæ which are ordinarily applied; but when

no formula was found to represent the experiments, and those available are *derived* formulæ expressing the relation between the travel and velocity or pressure, but not between the travel and the time, which the observations themselves give, it was decided to give the results of measurements for each shot separately, as a physical experiment independent of any previous theory.

Historical Sketch.

Two general physical methods have been employed in experimentally determining the pressures developed in the bore of a gun, viz., the Statical and the Dynamical method. In the former class come the early experiments of Count Rumford 1792, General Rodman's cutter gauge and that of Colone Uchatius, and Noble's crusher apparatus. In each of these the force which holds in equilibrium the force of the powder gas is the observation recorded and measured. The dynamical method of experimenting consists in investigating the motion of some body connected with the gun system so as to be under the influence of the expansive force of the powder gas, and from the circumstances of this motion, to pass by calculation from known laws of dynamics to the pressures required to produce such motion. In the application of this method, we find that study has been made of the motion of pistons, bullets, &c., caused to move by the products of decomposition, in a direction perpendicular to the axis of the bore; of the motion of the gun itself during recoil, and finally by investigating the motion of the projectile during its passage through the bore. In 1845 General Cavalli applied at various distances from the bottom of the bore of a 12-pounder smooth-bore field gun, a series of small musket barrels of wrought-iron arranged to throw spherical bullets under the action of the powder gases against a ballistic pendulum placed outside the gun, by which the initial velocity of the bullets were measured.

It was assumed that the quantity of motion communicated to the bullets at the different points along the bore, is a measure of the force of the powder gases at the corresponding sections of the walls of the gun.

An improvement upon this method was that adopted by the Prussian Artillery Committee in experiments conducted in 1854.* In these experiments a short gun-barrel was screwed into the wall of the gun opposite the center of the powder-chamber, and cylinders of varying mass ejected from it by the action of the

* Archiv für die Offiziere der Koeniglich Preussischen Artillerie und Ingenieur Corps. Revue de Technologie Militaire.

powder gases. By thus varying the mass of the pistons it was possible to vary the time of the action of the gases upon them, and from a knowledge of the velocity of projection of the cylinders as before, the pressures could be deduced, not only for the chamber itself but also at different points along the bore. In this same class are included the experiments in France with the accelerometer and the accelerograph of Marcel-Deprez, in which as before the powder gases actuate a piston which is made to move a known weight a certain registered height along a spindle, from which the velocity the piston had can be calculated, thus avoiding the great practical inconvenience of an exterior apparatus which must remain properly placed during the recoil of the gun, for measuring the velocity of the piston.

By knowing the spaces passed over by the gun in the direction of the axis of the bore, it is possible to deduce the law of change of pressure against the bottom of the bore. General Rodman was the first to construct a recoil velocimeter. The French Marine Artillery use the Sebert velocimeter, which consists essentially of a vibrating fork held in position, and describing the law of spaces upon a blackened steel ribbon which moves with the gun.

In all the dynamical methods thus briefly mentioned, besides being dependent in each case upon certain arbitrary assumptions as to the nature of the action of the gases upon the piston or other body as compared with its action upon the base of the projectile itself, they are open to the general physical objection that the desired data are derived and not directly observed.

In other words a fundamental rule of physical investigation requires the experimenter to direct his energy upon the study of the thing itself when possible in preference to observing other phenomena connected thereto and obtaining the desired result by processes of derivation. This fact of itself especially commends all dynamical methods which are directed to the observation of the law of motion of the projectile in preference to any auxiliary body, for we may be sure that the more complete our knowledge of the motion of a projectile during its passage through the bore, the more nearly can we approximate to the true law of change of pressure upon its base and the walls of the chase adjacent thereto.

In 1760 Chevalier D'Arcy calculated the pressure of the powder-gases at different sections of a musket barrel by successively shortening the length of the barrel and measuring the initial velocity corresponding to each length. This same method

has been successfully tried by several experimenters in recent years, notably the excellent experiments of Mr. L. V. Benet of the Hotchkiss Ordnance Co., Paris. The registering projectiles of Colonel Sebert for large calibers also represent one method of attacking the problem in a general way.

Another method has for its basis the determination of the times required for the projectile to pass over known distances along the bore. The experiments conducted upon this principle have employed chronographs specially constructed for the purpose, and have operated by causing a record of the instant the projectile reaches certain points along the bore to be secured by the projectile interrupting an electrical circuit at each of the prepared points. Notably among these experiments have been the classic work of Noble and Able employing the Noble Chronoscope; the experiments carried out by General Mayevski in 1867 at the Krupp factory in Essen, and the variations of the method employed in France using the Schultz Chronoscope.

Various attempts* have been made by the French Marine Artillery to record the passage of a projectile through the bore without mutilating the gun. In 1876 a method was tried in which a wooden rod of sufficient length to extend beyond the muzzle was attached to the projectile. On its extremity was fixed normally a sheet iron disk which, in the movement of the projectile, encountered successively interrupters placed on a strong wooden rule parallel to the axis of the gun, in front of the muzzle, and fastened to the chase of the piece by strong iron collars. The distances were measured along the rule and the times by a chronograph. This arrangement, which might answer for a gun of small length and a low velocity, failed with high velocity and a rifled gun. A better method has been found in the employment of interrupters glued in the bore, proposed by Mr. Letard. These interrupters, which may be placed in the bore to the number of five or six, are secured one after another by means of common resin. They are set in position by an expansion rammer with a movable wedge similar to those used for taking impressions of the bore with guttapercha. The insulated conducting wires attached to each interrupter pass out the muzzle to the chronograph. The devices being in place, their positions are determined by a measuring rule inserted at the muzzle. A difficulty experienced in this

* Extraits du Memorial de l'Artillerie de la Marine.
U. S. Ordnance Notes No. 313 by H. Sebert.

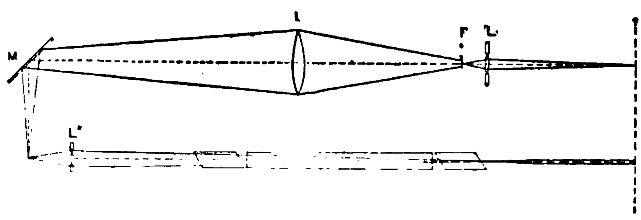
method was that the first interrupters and wires in being ejected were liable to strike the succeeding ones before the arrival of the projectile and thus give a false signal.

II. THE IMPROVED INSTRUMENT.

In a former paper already referred to, a full description of the instruments used was given. Many important improvements however, in details which add to the efficiency of the instrument, were developed during the progress of these experiments, although no change was made in any essential principle. The month of July was devoted to various necessary preparations to facilitate experimenting, which proved a great saving of time in the end; such as installing a suitable storage battery, constructing a universal mercury switch board, testing different carbon bisulphide tubes, perfecting tuning fork records, securing and testing a good projection lamp, &c. One of J. B. Colt's projection arc lamps was tried in the hope that a light might be found which would not show such variable illumination when subjected to the instantaneous test as those formerly used had done. The illumination obtained even with such a sensitive test as was applied remained perfectly steady, and compared favorably with sunlight, as a reference to any of the records will show. Having obtained a perfectly satisfactory source of artificial light energized by a storage battery, the great advantage over sunlight, in being always ready, need hardly be mentioned. Naturally the subject of sizes and forms of glass tubes for the carbon bisulphide, and the manner of obtaining the requisite ampere-turns, were matters of early consideration, and several tubes were obtained for test. It was found that, by introducing a condensing lens immediately in front of the arc, a greater intensity of light was obtained upon the plate than formerly.

One of the most unsatisfactory features of the original instrument was the small amplitude of the waves of the tuning fork, and special attention was given to improving this. The diagram (Fig. 1) shows the principle of an improved method of obtaining

Figure 1.



a fork record, which gave beautiful results and greatly increased the possible accuracy of such records. While the plan of optically magnifying the amplitude of the waves had already been successfully accomplished by us, yet the idea of further increasing the accuracy of such records had been beautifully carried out by Lieutenant B. W. Dunn, Ordnance Department, U. S. A., in some experiments which have unfortunately not yet been published. The same arc lamp was used for both the chronograph and tuning fork records. A plane mirror *M* reflected the light through a condensing lens *L* upon a thin piece of aluminium foil glued to one prong of the fork *F*. In this foil was a smooth round hole about one millimeter in diameter. A lens *L'* focused this brightly illuminated hole as an object upon the sensitive plate, and at the same time magnified it to about six millimeters. The fork was excited by drawing a wedge from between the prongs in preference to using any electrical method, as this was found to be convenient and satisfactory.

When one prong of a fork is allowed to cast its shadow through a narrow slit upon a moving plate the result is, that a single sinusoidal line divides the region of light from the shadow of the fork. At the same time the other edge of the fork gives another similar sinusoidal curve which is ordinarily separated from the first curve so as not to interfere. By having two slits near together one above another, a second shadow would fall on the plate having an exactly similar wave for its boundary, but it would lag behind the first wave by an amount depending upon the speed of the plate and the distance between the slits. This would therefore intersect the first wave at regular intervals of a wave length, and by the points of intersection make it possible to measure with great nicety the value of a wave length. Instead of having two slits the same object was attained by allowing the illuminated image of the magnified hole in the piece of aluminium attached to the fork to fall upon the plate. Those parts of the image which fell somewhat behind the rest gave waves differing in phase with the other part, so that results like those exhibited in Figs. 2, 3 and 4 were obtained. It is noticed that a cone of darkness intersects a cone of light, the dark region having had no exposure, and the light cone so to speak a double exposure. The fine circular lines seen are shadows cast by ordinary hairs fastened across the slit. They serve merely as reference circles by which the center of revolution may be accurately found. To allow the whole area of the magnified image of the illuminated hole to fall upon the plate, a square hole of suitable size was

filed away from the jaws of the camera slit opposite the point where the tuning fork record was to fall.

III. METHOD OF EXPERIMENTING.

After considering a number of different ways to measure interior velocities without mutilating the gun, that seemed to be the more promising, with the instruments in hand, which had for its fundamental idea the extension of the projectile forwards in the bore by some rigid body attached thereto, and measuring the motion of this prolongation assuming that it is the same as that of the projectile. The first trial of this kind was made on August 2, 1895, and proved to be unsuccessful. A wooden rectangular rod tapering towards the muzzle was pivoted by a brass cap on its base upon the point of the projectile, and it was expected that the projectile would turn in the rifling without turning the rod which was guided between two vertical supports fastened to the muzzle. Two long pieces of spring steel were firmly fastened to a wooden collar upon the muzzle. The ends of these were bent inwards to bear upon opposite sides of the rod about a foot in front of the muzzle. Strips of thin copper were fastened along the narrow edges of the rod at determined intervals on opposite sides, and electrically connected together in pairs. In position before firing the current is made, and passed from one spring through the first pair of copper strips on the rod to the second spring. When the projectile moves forward the springs first pass off from the copper upon the wood and break the circuit, and then on to the next copper strips restoring the circuit again and so on. The intervals along the rod between breaks are measured, and the times between the corresponding breaks ascertained by the chronograph. In the trial with this device, the record of the first break was observed but no succeeding make or break was recorded. Among other causes the chief difficulty seemed to be due to the blast preceding the projectile which raised the brushes off from the rod not to return again, though the springs were fairly strong.

The next attempt, on August 7th, was a device designed to utilize the blast, and make it aid rather than prevent the contact of the brushes upon the rod. A view of this arrangement just before firing is given in Figure 5. The rod in this case was made cylindrical and rigidly attached to a shrapnel projectile by taking out the fuse and screwing in the rod up to a shoulder. Its total length was about seven feet, and its diameter

an inch and a quarter. The copper strips in this case were wrapped around the rod and sunk into the wood flush with the surface. The interval from first to second break was 35.6 cms. and from second to third 106.5 cms. The brushes were made of sheet steel bent to a V shape and screwed to brass rods, at A and B in the figure, which served as hinges. The blast in pressing against the brushes encounters two surfaces on each brush inclined at such angles that the moments of rotation about this hinge oppose each other; but the outside surface of each brush was longer than the inside as shown to make the resultant moment cause the brushes to press against the rod instead of separate from it. This apparatus gave the first record of two points at 0 and 35.6 cms. obtained by us in interior velocities, but the last and only other point prepared did not appear on the chronograph record.

Weight of shrapnel projectile prepared to receive the wooden rod	12 lbs.	4 oz
Weight of wooden rod	1 lb.	14 oz
Total	14 lbs.	2 oz
Weight of charge (without sack)	3 lbs.	12¾oz

The result of this shot seemed to show that the difficulty experienced was in keeping two brushes in continuous electrical connection with the rod as it passed out. The centrifugal force due to the rifling also has a tendency to cause the rod to be displaced from the brushes. The rod being worked by hand was consequently not an accurate cylinder and the inequalities due to this cause became greatly magnified with such high velocities. These two points became forcibly impressed upon us; that the next shot fired should be with an accurately round rod and with a *single* brush if possible.

Electrical contact between gun and projectile.

The plan of using a single brush became more and more attractive, and a solution of the problem depended upon whether the projectile in passing out of the bore maintained throughout uninterrupted electrical contact with the gun itself. Accordingly the next step was an experiment to determine this point. On the afternoon of the same day, August 7th, this experiment was carried out, and indicated that such an electrical connection *is maintained* during the passage of the projectile through the bore. A shrapnel shell was fitted with a round ⅛-inch thick brass disc of slightly less diameter than the bore, placed upon the flat nose of the projectile and secured by screwing in the fuse. An insulated wire was attached to the nose of the projectile and passed

out at the muzzle. The object of the flat disc was to prevent the projectile from running over the wire and prematurely cutting it before the projectile left the muzzle. The rifling of the gun was very thoroughly washed with water, and the projectile polished in a lathe until it was bright. The two line wires from the chronograph were joined respectively to the projectile and gun. To secure contact with the gun the rear sight seat was removed and its screw served as a binding post. A make device described in the previous paper was placed at a determined distance in front of the muzzle and the terminals of the chronograph also extended to it. The object of this additional circuit was to determine where the interruption of the current by the projectile in its passage occurs, whether near the seat, or near the muzzle. This may be done by estimating the time between the break and the succeeding make on the negative and noting the corresponding distance on the trajectory. This comparison indicated that the break occurred near the muzzle and metallic contact is maintained.

A single ring brush.

The possibility of utilizing a single ring brush according to the plan conceived seemed now established. This plan involved making the gun itself one terminal of the chronograph circuit, thus utilizing the connection between projectile and gun as one of the brushes. From the projectile the current passed along a wire, imbedded in the wooden rod and connected with all of the copper bands, to the single brush at the muzzle which formed the other terminal of the chronograph. As a single brush could now be used, the advantages of one in the form of a ring entirely encircling the rod were at once apparent, for no matter which way the centripetal force urges the rod, a good contact with the ring is always assured, and furthermore the same ring may serve as a guide for the rod in its passage out of the bore.

The accurate cylindrical rod.

Attention was next directed toward obtaining a perfectly true round rod. The necessity of this requirement may not appear so serious at first thought, but keeping in mind the high velocity of the moving rod, the case may be likened with advantage to that of a railroad train moving at the rate of a mile a minute upon poorly ballasted track, compared with the smooth gliding of a train at the same speed on a good road bed. The question of the most suitable material for a rod was considered. The great mass of a metal rod of suitable size and length, and the

difficulty of preparing insulating bands upon it, pointed to the use of wood as the preferable material, and finally a fine piece of light white pine was chosen as the kind of wood to be used. The great length of this rod which was only 1⅝ inches in diameter, made it impossible to turn it when supported in the lathe by its extremities alone. An attempt to place a third support in the center caused much annoyance by chattering when run at a sufficiently high speed. Finally a special tool was made which would support the rod and at the same time cut it to a true cylindrical shape. An iron collar with a hole just equal to the diameter of the desired rod was supported from the tool rest, and a specially made knife screwed upon this collar with its cutting edge turned so as to cut the wood in front of the collar as it advanced, down to a size which would just fit the hole. As the tool advanced the rod was polished by the friction in this collar which left a perfectly smooth and accurately finished rod. Notches were then cut at the desired intervals to accommodate the copper bands, which must be flush with the surface of the rod, by simply lowering the knife and running the tool in the opposite direction along the rod. This was done so that the tool would never come upon a smaller portion of the rod, since it served for a support.

Copper conductors added to the rod.

When the rod was turned a groove was cut along its entire length to accommodate a copper wire to be buried in it. Thin copper strips $\frac{1}{32}$ inch thick were cut to the desired lengths, and each made just long enough to completely encircle the rod without overlapping. These strips were first rounded between rollers, then wrapped around the rod and drawn very tight and close by winding a leather strap around it and drawing taut. Each edge was then secured by driving small brads closely along its length near the seam. The imbedded wire was next soldered to each strip of copper to secure good contact. Between the copper bands, in addition to the wire being sunk beneath the surface of the wood, further guard against metallic contact with the brush as it passed through was afforded by filling the groove flush with the surface with sealing wax. The rod was next replaced in the lathe and polished to an accurate smooth surface. A view of the rod prepared for use is shown in Figure 6. The shrapnel was bored out from the front to the base part with an inch drill to compensate for the additional mass of the rod, and a wooden plug driven in to give a firm bearing surface for the base of the ballistic rod. A collar was turned upon the

nose of the shrapnel to receive the ballistic rod which was firmly screwed in position. The wire imbedded in the rod was securely fastened to the projectile. At first this contact was secured by simply screwing down the rod thus pressing the wire upon the shoulder. Later, when the supply of unloaded shrapnel was exhausted, and it became necessary to use common shell, this method of securing contact was no longer reliable, as there were no screw threads in the projectile. It was more labor to prepare one of these common shell, as the front portion had to be cut off to make a bearing shoulder, and a hole bored through to the central cavity to admit the wire. Advantage was taken of the base percussion fuse to ensure good electrical connection. The fulminate and plunger were removed and the cavity filled with mercury, into which the wire passed through the perforation in the vent, originally intended to admit the flame to the cavity. This arrangement of mercury cup contact, thus found already made, was as good as though especially designed for the purpose. After each rod and projectile were prepared they were carefully tested for good electrical contacts, since experience proved that contacts supposed to be perfect were sometimes defective, and neglect of this precaution would have lost much time.

Spacing of the copper strips.

By any "dynamical method" the observations give points along a space-time curve. Since the number of these points is necessarily limited, their value greatly depends upon their position along the curve. The ideal positions of these points would seem to be at regular intervals along the arc of the curve itself. The form of the space-time curve is known to be such that observations at equal time intervals more nearly conform to the ideal than at equal space intervals. This also has the practical advantage of using the chronograph itself under the most favorable conditions. The copper bands should therefore be of varying lengths, the shortest being at the point of the rod. Accordingly for a first trial these lengths were approximated to in a rough way by simply taking the space-time curve to be a parabola, and the nearness of the approximation may be seen by the location of the observed points on the space-time diagrams given with each shot. Each negative was examined before the intervals on the rod for the succeeding shot were determined. Naturally the first attempts had only a few long intervals along the rod, and these were made shorter and shorter in succeeding shots to determine how near together the records might be easily

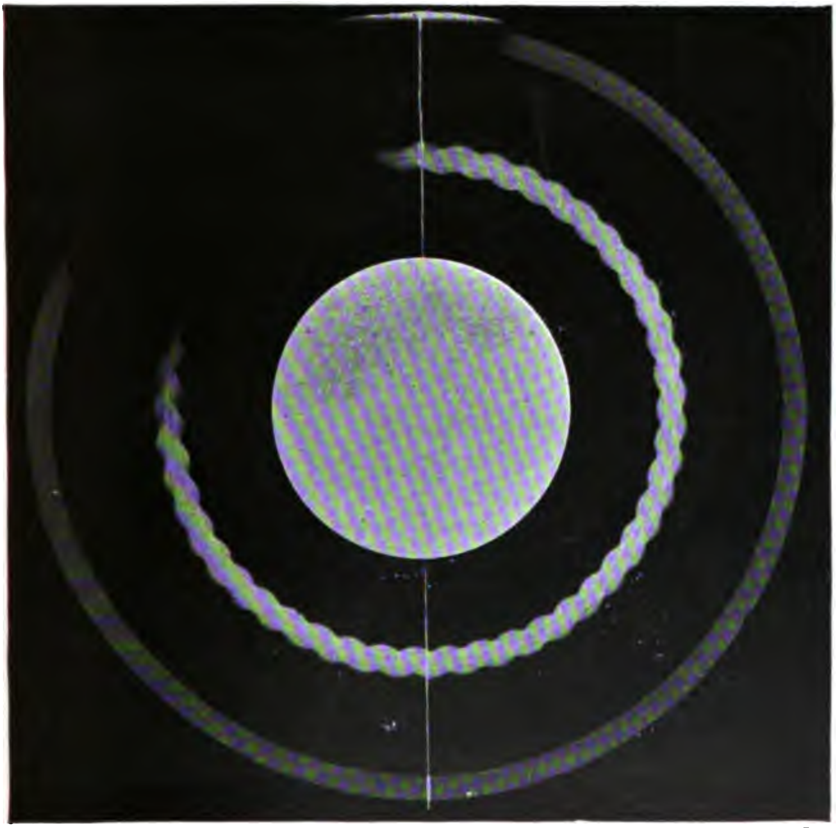


FIGURE 2.

Tuning fork, 1024 (single) vibrations per second.

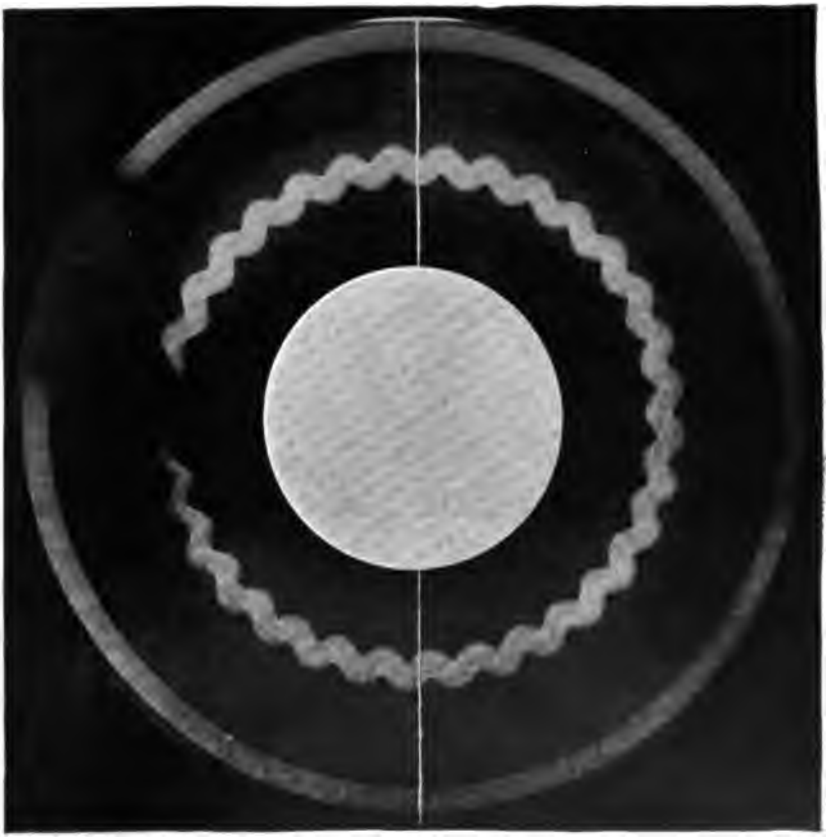


FIGURE 3.

Tuning fork 512 (single) vibrations per second.

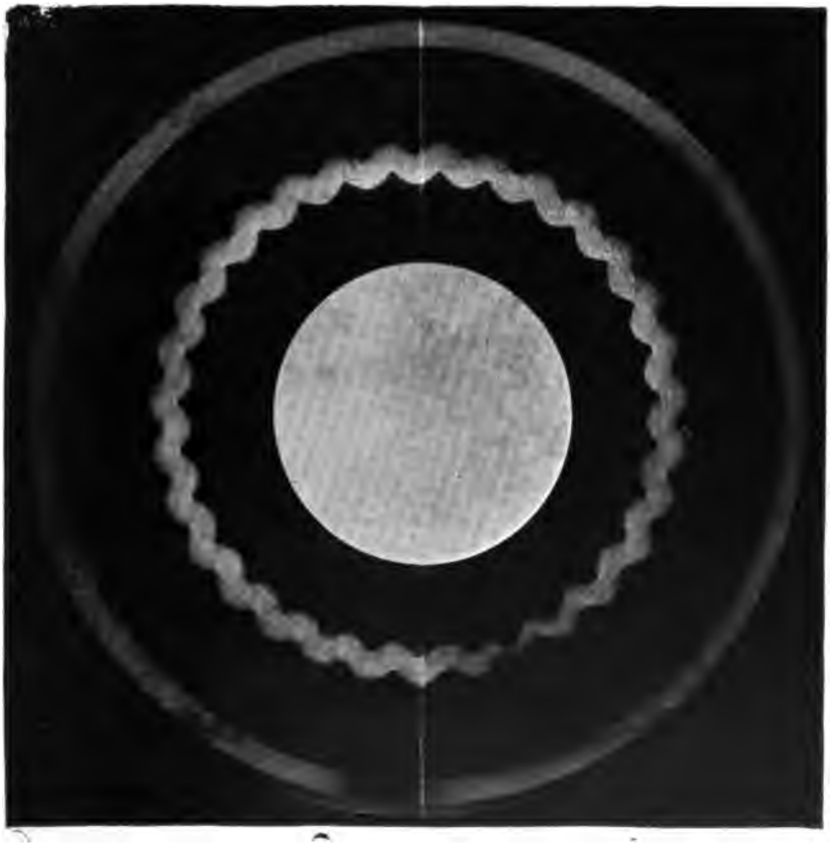


FIGURE 4.

Tuning fork 512 (single) vibrations per second.

FIGURE 5.

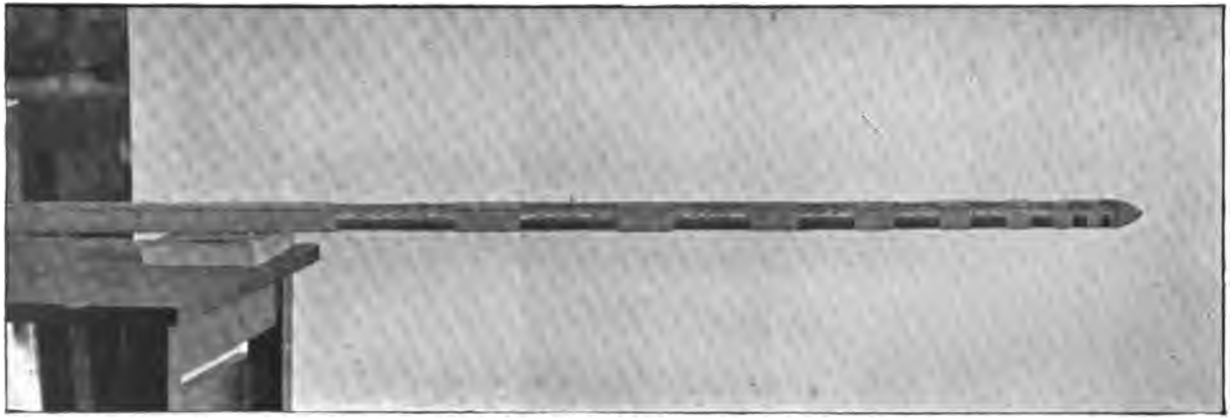


Figure 6.

FIGURE 8.

FIGURE 8.

obtained. Beside this, another idea kept in view in designing rods was to cause the observations of succeeding shots to fall intermediately between those of previous shots, so that the number of points would be greatly increased along a resultant curve reduced from all the shots. The intervals along the prepared rods were carefully measured with a steel millimeter tape, estimating to tenths of a millimeter.

The "spider ring brush."

A single ring brush being possible, a new device for supporting it at the muzzle was constructed. A view of this device is shown in Figure 7. A A is the wooden collar turned to fit the front of the chase, and prevented from displacement forward during discharge by the swell of the muzzle of the gun. BB are circular iron straps capable of adjustment, for securely holding the collar in position. The wooden collar was slit into four equal sectors and the hard steel pieces CC, DD, extending the length of the collar were securely screwed, one to each sector, to facilitate taking apart and assembling the support. The entire collar and steel strips were insulated from the gun by the insulating wood of the collar itself, and by wrapping tough paper upon the gun and assembling the collar over it. E E, F F are four other iron strips bolted to the former pieces as shown, and capable of adjustment along radii by means of slots for the securing bolts. These radial pieces served as immediate supports for the ring brush, which was grasped by four half circular holes in the inner edges of the radial strips. The form of the brush first used was an iron ring slightly larger than the rod, but experience finally led to the "spider ring brush" shown in the figure. This is made of $\frac{1}{4}$-inch brass rod bent into a circle of $1\frac{3}{4}$ inches internal diameter. Into this ring were driven spring brass wires $\frac{1}{20}$-inch in diameter projecting $\frac{1}{2}$-inch in front of the ring and inclined at an angle inwards so as to press against the rod. These spring wires were added to insure a continuous connection with the rod, and cause the breaks in passing from copper to wood to be uniform and definite for each of the strips, since some of the spring wires are in contact at all times. One of the greatest advantages of this ring brush with its four radial supports is that it offers a very small surface to the action of the blast. A front view of the muzzle device with simple ring brush is shown in Figure 8.

Pieces of the rod recovered.

It was naturally a point of great interest to know exactly how the rod behaved in passing out through the ring, independent of the chronograph record, which never gave a complete record throughout the whole length of the bore. The gun was pointed out to sea, and at the instant of firing nothing unusual could be observed, but an instant later the front part of the rod could be seen floating in the water about 500 yards distant. This part of the rod was recovered after each shot. The rods thus obtained were all of about the same length, and the fractured end showed in each case a similar cross break. The scratches along the copper strips made by the small spring wires of the ring brush were clearly visible, and also showed the rotational effect due to the rifling. Complete contact across each copper strip by some one of the spring wires of the brush could be traced. This corresponded to the record of the chronograph, and the break in the rod limited the extent of the observations to about 80 cm. along the rod which corresponds to the first 80 cm., or about 2.62 feet of the travel of the projectile. None of these pieces recovered showed any increase of blackening from the blast, but they certainly would have done so if such had been the case, for the polished surface of the copper was very susceptable to discoloration when even temporarily placed in a gun recently fired and ordinarily cleaned.

Though the break in the wood prevented records being obtained throughout the entire length of the bore, yet the points obtained thus far by this method extend about half the travel of the projectile. Fortunately observations in the first half of the travel are most desired, as here occurs the point of maximum pressure and the greatest variations of all kinds. Moreover this part of the curve needs more study than the other part, since the errors of observation are greater, and a less number of accurate experiments are known for this portion.

The ground immediately in front of the gun was carefully examined after each shot and narrow furrows along the trajectory cut in the turf were often discovered. Besides this small splinters of the rod and portions of copper strips were picked up.

Brass bolts were employed to fasten the radial strips (E E and FF, Fig. 7) which support the ring brush, to the longitudinal steel strips, so that, by the shearing of these brass bolts as the projectile passes out, the ring and radial strips alone are carried away at each shot. This greatly reduced the labor in the preparation of each shot, for the entire muzzle collar and steel strips

were unharmed and were used throughout the experiments. The only parts of the muzzle apparatus destroyed with each shot were the ring, the four iron radial strips and the brass bolts, and these could be prepared in quantity and ready for use. Since in these experiments it was necessary to examine the previous shot before deciding upon the spacing of the copper strips for the next shot, this delayed the workman somewhat; however, as it was, with a single mechanic, working an ordinary day, a speed of one shot per day was attained for two successive weeks.

The gun was uniformly fired at a quadrant elevation of 3° and the muzzle preponderance caused by the weight of the chase-collar and brushes was counterbalanced by wrapping the prolonge over the breech and underneath the trail, thus preventing the depression of the muzzle and insuring the given elevation.

IV. REMARKS ON OBSERVATIONS.

It is an advantage to have observations given in a graphical as well as tabular form, and accordingly they are presented by points indicated by crosses through which broken dotted lines are drawn. The importance of the graphical method of viewing problems of this character, exhibiting to the eye the fundamental relations which connect the different equations together, and making it possible to pass from one curve, which is the geometrical equivalent of an equation, to another in cases where the equations may be either unknown or very complicated, so that the equivalent process of algebraic elimination is impracticable, it seems has not been sufficiently emphasized, and it is for this reason that it is thought the elementary character of the following explanations will be acceptable:

Without any special reference to ballistics, let us consider the abstract problem of the motion of a point along any line in space. Referring to Fig. 9, let the position of this moving point at any time be represented by the curve ABC. Time t is measured along the horizontal and the distance s from the origin along the vertical axis. Thus a point C upon the curve means that the moving point had moved six meters from the origin in three seconds. As an example, suppose it to be known that the motion is represented by the equation

$$(1) \qquad s = t^3 - 3t^2 + 2t.$$

in which s is the distance from the origin of motion in meters, and t the time.

Curve I is a representation to scale of this equation, and does not in any way represent the real path of the point in space, which

which may be along a line of any kind, but it is simply a scheme of showing how far the point is from the origin at any time. To interpret this particular curve it is seen that the point starts at the origin and moves in the plus direction for 0.423 of a second when it comes to rest, and then reverses its direction, arriving at the origin again after one second. The motion is then in the opposite or negative direction from the origin and so continues till it comes again to rest after 1.577 seconds. It then returns to the origin and arrives there again after two seconds, and thereafter continues to depart from the origin in the positive direction. This is known as the space-time curve. The velocity with which the point moves is algebraically represented by the first derivative of s with respect to t.

$$(2) \qquad \frac{ds}{dt} = v = 3t^2 - 6t + 2.$$

But graphically the derivative is represented by the tangent of the angle which a line drawn tangent to the space-time curve at any point makes with the time axis. Such a tangent is drawn at B, and its value is seen to be $+2$.* At this point an ordinate is drawn equal to $+2$, and this gives one point on the velocity-time curve, as the point D. Any number of points could be similarly found and a continuous curve drawn through them. This curve thus graphically determined is the same as a curve representing equation (2), and in this case is seen to be a parabola. To interpret curve II physically, beginning with the point E it is seen that the velocity of the point just starting from the origin is equal to 2 and in a positive direction, and by moving along the curve it is evident that the velocity is decreasing. At the point N where the curve crosses the axis, the velocity is zero and the point at rest after 0.423 seconds, which was also evident from curve I. The velocity then becomes negative and reaches a maximum negative value after one second, and this occurs when the point, as seen by curve I, has returned to the origin. In this way many features are readily detected by the eye which would not appear evident at a glance from the equation.

The acceleration which the point has is algebraically expressed by the second derivative of s with respect to the time, which is

$$(3) \qquad \frac{d^2s}{dt^2} = a = 6t - 6.$$

* Due to the different units used on the horizontal and vertical axes, the real angle is not the same as it would be when drawn to equal scales, but the tangent of the real angle is always found by taking the ratio of the sides of a triangle, measuring the vertical side by the vertical scale and the horizontal by the horizontal scale.

This second derivative is also represented by a curve which may be derived graphically from curve II, as II was from I. When this is constructed, the points will lie upon the straight line III, which crosses the t axis at a point directly above the lowest point of the parabola, where $t = 1$, since here at the minimum point the tangent is zero and the velocity is not changing. Equation (3) when traced coincides with this line, which represents the acceleration-time curve, and indicates that the law of motion of the point is a uniformly increasing acceleration.

The more desirable relations required in interior ballistics are those between velocity and space, and between acceleration (or pressure) and space, so as to know what the velocity or pressure is at any point of the bore. These relations may be derived graphically from curves corresponding to I, II, and III by a process to be described. This may sometimes be done algebraically, but the process involved consists in eliminating one variable between two equations, which in general is not a simple problem. If the variable t is eliminated between equations I and II, the desired velocity-space equation will be obtained, and the result seen to be a higher degree equation. The graphical solution of this however is simple and represented in Fig. 9 by curve IV. To obtain this make use of curves I and II. To obtain any point as M on the new curve, measure the ordinates of curves I and II, corresponding to the abscissa OH, and take HK as the abscissa, and HG as the ordinate of the new point. This locates the point M on the new curve and a similar construction gives any point on the velocity-space curve. By eliminating t between equations (1) and (3) the acceleration-space curve is obtained, or graphically by a similar construction as before between curves I and III, the points of curve V are obtained, which is the required acceleration-space curve.

Data.

The data obtained from each shot prepared to give a record of interior ballistics, together with that from the chronographic negatives, are given below, and no attempt is made to derive an equation to represent the velocity and acceleration or pressure throughout the bore, except in cases where five or more points are obtained on the space-time curve.

The powder used throughout these experiments was I.K.H. Dupont Powder, 1891, lot 27, 3.2-inch breech-loading rifle. Specific gravity 1.725. Volume of chamber with shrapnel 111.367 cu. in. The density of loading with shrapnel is .95713 and the reduced length of initial air space 0.5022 ft. Volume

of chamber with shell 104.55 cu. in. This difference in volume of chamber with shrapnel and shell is due to the difference in the position of the band.

Shot I.

August 7, 1895.

Weight of projectile,	12 lbs. 4 oz.
Weight of rod,	1 lb. 14 oz.
Total,	14 lbs. 2 oz.
Weight of charge (with sack)	3 lb. 14 oz.

This shot is the one previously described using the method represented in Fig. 5.

The distances s are measured along the rod from the inner side of the copper band nearest the muzzle, which was in each case so adjusted that the first movement of the projectile from its seat would break the chronograph circuit. This is evidently the zero point from which to measure the travel of the projectile. The angles θ are measured upon the negatives from that break of the chronograph record, which corresponds to the first motion of the projectile just mentioned. The corresponding time is obtained from θ by the relation $t = \frac{\theta}{\omega}$ which holds for uniform rotation where ω represents the angular velocity of the plate. The angular velocity ω is obtained from the tuning fork record by measuring the angle so obtained by any convenient number of complete waves. The angle subtended by 22 waves in this case is 216.285 degrees, and the time corresponding to one complete wave of the fork used is known to be $\frac{1}{256}$ of a second. This determines the angular velocity which is $\omega = 2516.8$ degrees per second.

No.	s (cms)	θ (degrees)	t (seconds)
1	35.6	11.067	.00440

Shot II.

August 14, 1895.

The first shot with the chronograph circuit through the projectile and gun.

Weight of projectile,	11 lbs.	13 oz.
Weight of rod,	3 lbs.	10 oz.
Total,	15 lbs.	7 oz.
Weight of charge,	3 lbs.	13½ oz.

278.692 degrees of tuning fork record correspond to 27 waves. Hence

$$\omega = 2642.4 \text{ degrees per second.}$$

No.	s (cms)	θ (degrees)	t (seconds)
1	19.1	9.271	.00351
2	76.25	17.900	.00677

Shot III.

August 19, 1895.

First trial with the "spider ring brush."

A tuning fork of higher pitch was first used for this shot, and continued to be used for all remaining shots. Its frequency was 511.601 complete vibrations per second.

Weight of projectile, 11 lbs. 13 oz.
Weight of rod, 3 lbs. 5 oz.
Total, 15 lbs. 2 oz.
Weight of charge, 3 lbs. 13 oz.

185.372 degrees of tuning fork record correspond to 23 waves. Hence

$$\omega = 4123.4 \text{ degrees per second.}$$

No.	s (cms)	θ (degrees)	t (seconds)
1	5.75	6.114	.00148
2	22.92	12.528	.00304
3	52.20	18.792	.00456

Shot IV.

August 21, 1895.

Weight of projectile with rod, 15 lbs. 5 oz.
Weight of charge, 3 lbs. 13½ oz.

214.922 degrees of the tuning fork record correspond to 28 waves. Hence

$$\omega = 3927 \text{ degrees per second.}$$

No.	s (cms)	θ (degrees)	t (seconds)
1	5.78	5.934	0.001511
2	22.92	14.583	0.003713
3	52.14	22.599	0.005755

Shot V.

August 23, 1895.

Weight of projectile with rod, 15 lbs. 2½ oz.
Weight of charge, 3 lbs. 13½ oz.

$$\omega = 5933 \text{ degrees per second.}$$

No.	s (cms)	θ (degrees)	t (seconds)
1	3.81	5.433	.000916
2	10.19	10.744	.001811
3	19.09	16.079	.002710
4	31.14	21.114	.003559
5	48.94	26.011	.004384
6	71.80	31.917	.005380

Shot VI.

August 24, 1895.

Weight of projectile,	11 lbs. 12	oz.
Weight of rod,	3 lbs. 1	oz.
Total,	14 lbs. 13	oz.
Weight of charge,	3 lbs. 10½	oz.

$\omega = 6131$ degrees per second.

No.	s (cms)	θ (degrees)	t (seconds)
1	3.85	5.278	.000861
2	9.60	9.439	.001540
3	17.80	13.386	.002183
4	28.00	17.994	.002935
5	40.77	22.798	.003719
6	57.30	27.717	.004521

Shot VII.

August 26, 1895.

The unloaded shrapnel on hand had been exhausted and common shell was used first with this shot, and with all following ones.

Weight of projectile with rod,	15 lbs. 7	oz.
Weight of charge	3 lbs. 13½	oz.

267.075 degrees of the tuning fork record correspond to 23 waves. Hence

$\omega = 5940.8$ degrees per second.

No.	s (cms)	θ (degrees)	t (seconds)
1	3.81	4.472	.000753
2	9.60	9.366	.001577
3	17.86	14.105	.002374
4	27.90	17.955	.003022
5	40.66	21.952	.003695
6	57.15	26.239	.004417

Shot VIII.

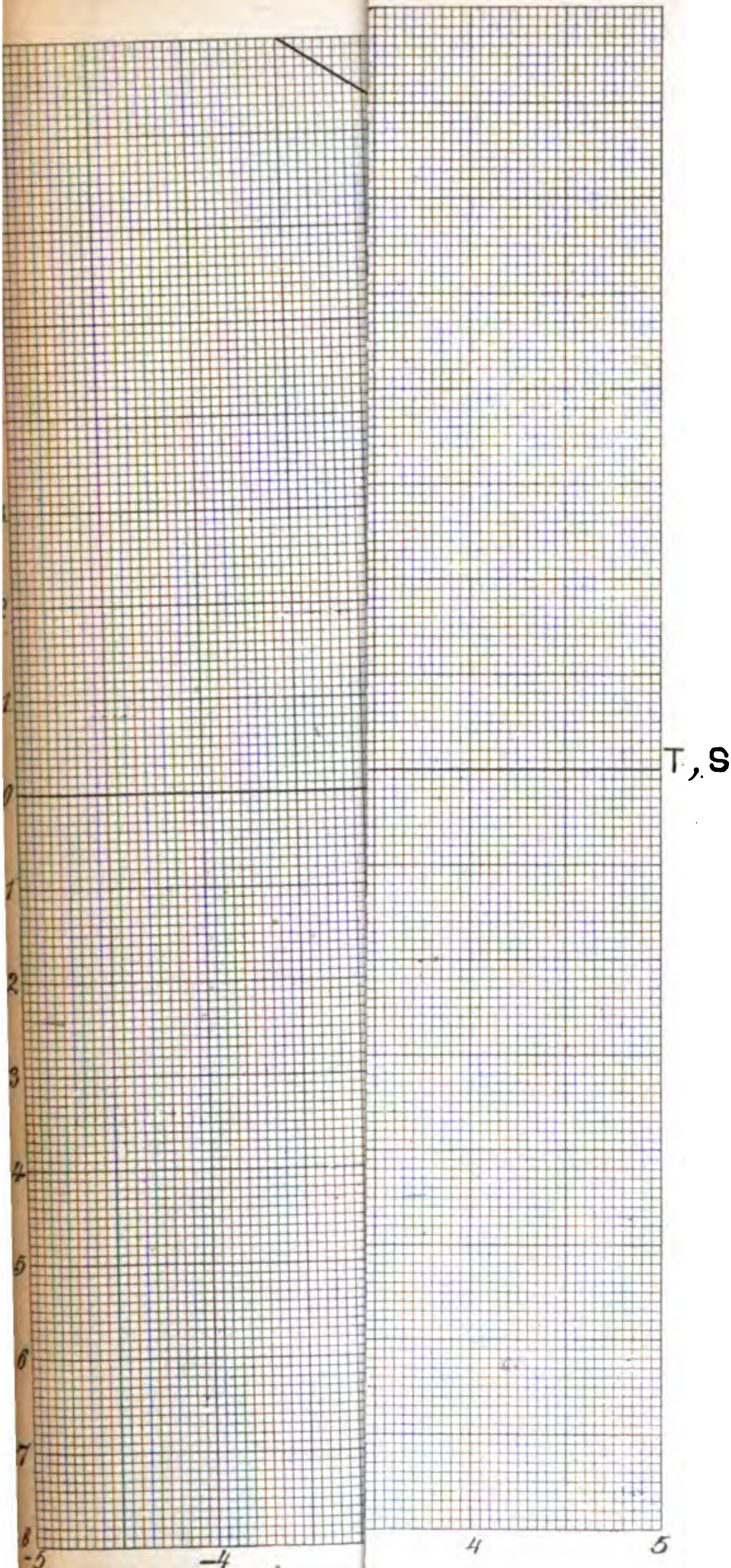
August 27, 1895.

Weight of projectile,	11 lbs. 13½	oz.
Weight of rod and mercury,	3 lbs. 13	oz.
Total,	15 lbs. 10½	oz.

A mercury cup connection was first used with this shot as previously explained.

Weight of charge, 3 lbs. 13½ oz.

$\omega = 5883.4$ degrees per second.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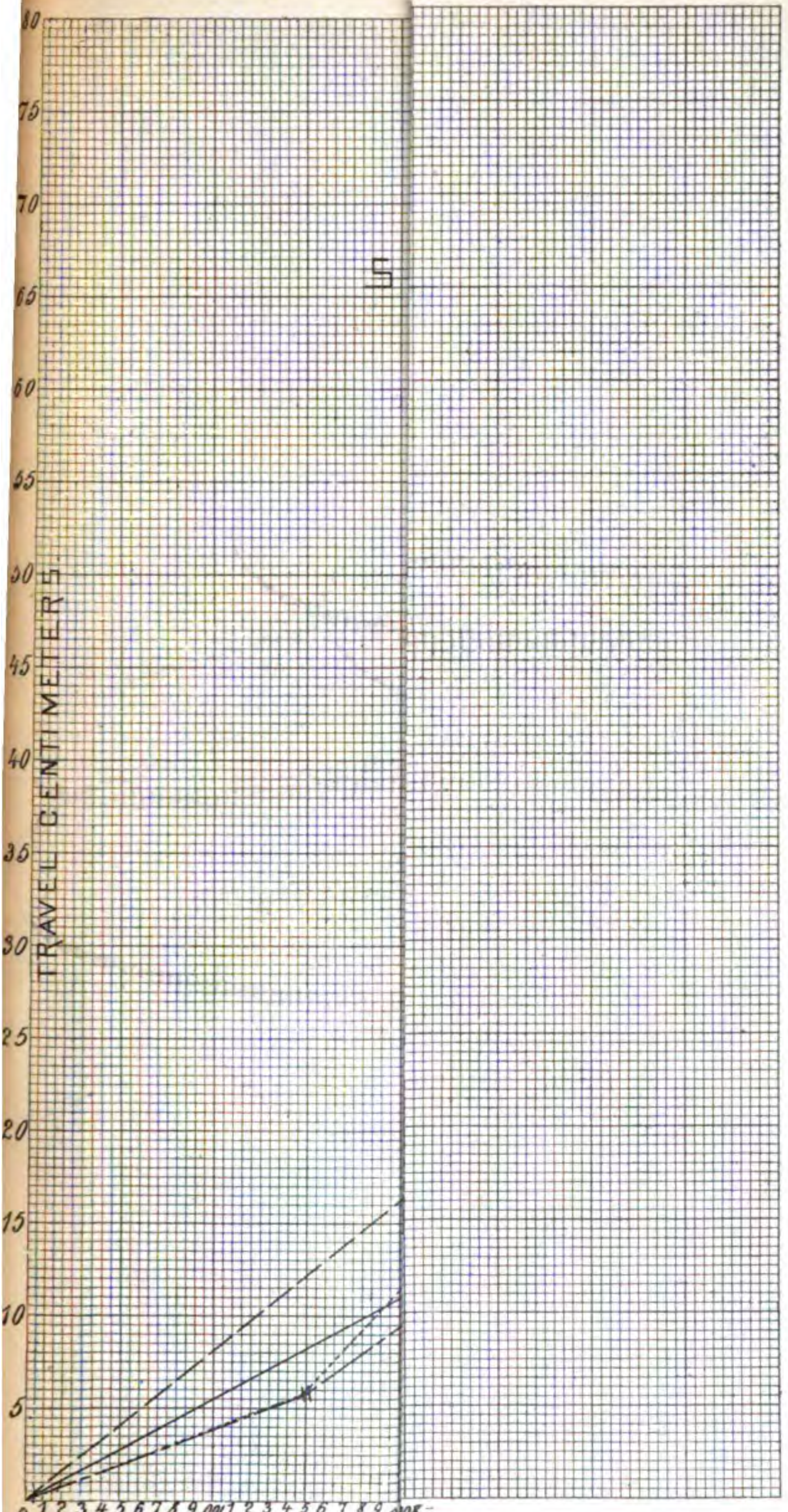
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No.	s (cms)	θ (degrees)	t (seconds)
1	3.40	4.222	.000718
2	8.90	7.392	.001256
3	16.40	10.903	.001853
4	26.35	15.031	.002555
5	39.40	19.261	.003274

Shot IX.

September 3, 1895.

Weight of projectile,	11 lbs.	14½ oz.
Weight of rod,	3 lbs.	4 oz.
Total,	15 lbs.	2½ oz.
Weight of charge,	3 lbs.	13½ oz.

$\omega = 5514.8$ degrees per second.

No.	s (cms)	θ (degrees)	t (seconds)	mean error of t
1	5.8	5.499	.000997	.0000196
2	13.85	10.341	.001875	.0000316
3	23.86	13.746	.002493	.0000285
4	35.85	17.794	.003227	.0000277
5	49.82	21.553	.003908	.0000187
6	65.80	25.548	.004633	.0000232

The muzzle velocity was found for a weighted projectile by means of three exterior screens, and the crusher pressure gauge was also used.

September 2, 1895.

Weight of projectile,	15 lbs.	14 oz.
Weight of powder,	3 lbs.	12¼ oz.
Weight of sack,		1¼ oz.

213.66 degrees of the tuning tork record correspond to 22 waves. Hence

$\omega = 4968.6$ degrees per second.

The distance from the muzzle to the various screens prepared is denoted by s.

No.	s (feet)	θ (degrees)
1	19.77	0.000
2	29.80	32.334
3	40.13	65.638

The first break in the chronograph record occurred at the first screen 19.77 feet from the muzzle. The velocity calculated from the interval between the 19.77 and the 29.80 points is 1541.2 ft. per second. That calculated from the 29.80 and 40.13 interval gives 1541.1 ft. These velocities expressed in meters per second are 469.73 and 469.77. If the former experiments in

determining exterior velocities are taken as a guide, some of this observed velocity at a distance of twenty feet should be deducted to obtain the true muzzle velocity. From previous measurements it is not too much to say that the muzzle velocity is thirty or forty feet less than the observed value, which would bring it down to about 1500 ft. per second or 457 meters per second. It will be remembered that the corresponding velocity for service conditions when the shell is not weighted measures in the neighborhood of 1650 feet per second, and is thus about a hundred feet per second greater than the velocity just given.

The crusher gauge registered a pressure of 34,000 pounds per square inch.

The measurements given for shots 1, 2, 3 and 4 are represented graphically in Fig. 10 and for shots 5, 6, 7, 8 and 9 in Fig. 11. The points represented by crosses are observed points, and those belonging to a single shot are connected by broken lines. It will be noticed that the observed points only extend through the first 72 cm. of the bore, which is itself (measuring from the base of projectile in its seat to the muzzle) 184.4 cm. long, and thus the observations extend through almost half the travel of the projectile. In this distance the greatest number of points observed is seven, and these are all recorded in $\frac{5}{1000}$ of a second. Some of the intervals of time between successive breaks are as small as $\frac{5}{10000}$ of a second. The shortest distance between the observations of the projectile was 3.8 cm. or 1.48 ins., which is even less than the diameter of the wooden rod, namely, 1⅝ inches. The only practical limit to the nearness at which observations may be taken by the chronograph seems to be due to the fact that if too large a current is used it is liable to arc across from one copper band to the next, and if the inductance of the circuit is not small the current does not increase fast enough at the make. It will be remembered that the inductance of the circuit is capable of being made very small because of the absence of any iron whatever from the circuit. Considering the shortness of these intervals it is encouraging to find how nearly the points lie upon smooth curves. To see this refer to Fig. 12 where the observed points for shot No. 7 are again represented. To find the velocity-time curve from the observed points on the space-time curve, divide the space increment by the time increment between successive points and obtain the points indicated by the broken dotted line II. It is seen that these points do not follow any pronounced curve, and inspection shows that a straight line suitably located represents the points within the

limits of error as nearly as any curve. This suggested trying the velocity-time curve as a straight line, which of course means that the space-time curve must be a parabola, and finding the parabola which would most nearly pass through the observed points. Curve I shown in the figure is a true parabola whose equation is $s = 2,830,000.\ t^2 + 2.12$ where s denotes travel in cms. and t time in seconds.

The first observed point does not lie upon the parabola so closely as the others, which it will be seen is to be expected. The third point, which is seen to be the farthest from the curve, differs from the curve in point of time by about a single small square or $\frac{25}{1000000}$ of a second.

As soon as it was found that a parabola could be fitted to the observed points as closely as this, there was no reason to try other and more complicated formulae than that of a parabola, which are usually advocated.

The equation of the velocity-time curve, found by differentiating the former equation with respect to t, is $v = 56,600\ t$, where v is expressed in meters per second, and t in seconds. The velocity-space curve found by eliminating t between the two equations given is $v^2 = 11.32\ s - 24$ and is also a parabola. The acceleration-time equation is found by differentiating the velocity with respect to t, and is $a = 5,660,000$ cm. per second, which is 5,740 times the acceleration of gravitation, and is constant. Since acceleration is directly proportional to the pressure on the projectile (neglecting friction) it follows that the pressure over the distance where the parabola coincides with the observations is approximately constant. It must not be inferred from this statement that the parabolic law involving constant pressure, found to be so approximately true through a certain range of the travel, obtains for portions of the bore either in rear of or in advance of this region. In fact, it is well established, especially for quick burning powders, that the pressure sensibly decreases along the chase. As to the very first motion of the projectile which caused the first signal on the chronograph, it is seen from this and succeeding figures that the first point invariably lies below the parabola and usually considerably off from it as compared with the others. This of itself indicates that there is considerable departure from the parabolic form, and it seems to be confined to the first few (about five) centimeters from the origin, corresponding to about $\frac{1}{1000}$ of a second. In other words, for the powder used and the conditions of loading employed, the point of maximum pressure seems to be located within this

region. In any case this is the region of greatest changes of all kinds, and although most important to know as far as gun construction is concerned, yet it is the most difficult to measure. It seems clearly settled however that this maximum point, under the above named conditions, lies nearer to the origin than has heretofore been supposed. We have only succeeded thus far in obtaining a single point that seems to lie within this region of maximum pressure, which is manifestly far from being sufficient to determine the exact position of it; but if slower burning powder had been used it looks quite probable that the maximum point might be approximately located.

The pressure which corresponds to the constant acceleration of 5,660,000 cm. per second, or 5,740 g, is found to be about 11,100 pounds per square inch on the base of the projectile, which weighed 15 pounds, 7 ounces. This value, which is the probable pressure along the part of the bore where the parabola applies, it will be seen might have been much greater near the seat of the projectile without making very much change in the space-time or velocity-space curves. To illustrate this point some dotted curves are drawn in figure 13, which figure represents the data from shot number 9. The parabola in this case representing the space-time curve has its origin to the left of the vertical axis instead of upon it as in the previous case. The true space-time curve must manifestly pass through the origin as the time is counted from the instant when the projectile started. It apparently blends with the parabola in a very short time. The dotted curve from the origin represents a possible position of the true curve which soon blends with the parabola. Now, assuming that this is the true curve, the other curves may be graphically found. The points on the velocity-time curve II are obtained by erecting ordinates equal to the tangent of inclination to the space-time curve I. It is evident also that the velocity-time curve must pass through the origin, since the velocity is zero when the time is zero. This shows that curve I sbould be tangent to the horizontal axis at the origin. As the curves are drawn there is a point of inflection in the velocity-time curve at A, and a tangent line is drawn at this point. It will be remembered that the pressure on the base of the projectile is proportional to the tangent of the angle which the tangent line drawn at any point of this curve makes with the horizontal. This point would therefore correspond to the point of maximum pressure, as the tangent has here its greatest value. This particular inclination is chosen because it corresponds to a pressure

of 34,000 pounds per square inch, which is the registered pressure of the crusher gauge. It is noticeable here how a small change in the inclination of this line will make a great change in the pressure. This great pressure may have actually existed for a very short time near the beginning of the travel, but it looks somewhat doubtful that such a large value did exist.

In connection with this subject we cannot omit to mention that theoretically the pressure *recorded* by a crusher gauge when the pressure is *suddenly* applied (and this means instantaneously), is just twice as much as that which would be recorded by the same pressure slowly applied, as it is when the copper cylinders are tested. Now the fact that the maximum point seems located so near the origin, meaning that the pressure is very suddenly applied, would perhaps cause the crusher gauge to register more nearly the theoretical limit of double pressure than that which the testing machine gives. At any rate it would be somewhere between these two limits, as the pressure is surely not slowly applied, and, not having any experiments to show which limit is actually nearer to the truth, it must be entirely a matter of judgment to decide this question. According to this statement the true maximum pressure lies somewhere between 34,000 and 17,000 pounds per square inch as indicated by the crusher gauge, and it remains to the judgment to decide which is the nearer limit. The value which certainly exists further along the bore in the region we have measured is less than the smaller limit.

It is naturally of interest to see what muzzle velocity the parabolic law gives, assuming it to hold for regions of the bore in front of the observations. The travel of the projectile using common shell, meaning the distance from the base of the projectile in its seat to the muzzle, was measured to be 184.4 cms. In the case of shot No. 7 the equation for the velocity space curve is $v^2 = 11.32\, s - 24$. Substituting the muzzle distance for s we have $v = 446.2$ meters per second. In case of shot No. 9 the corresponding computed velocity is 423 meters, and for shot No. 5 it is 421 meters.

It was impracticable to measure the muzzle velocity with each shot in the ordinary way by exterior screens, because of the ballistic rod which projected in front of the projectile. Accordingly a special experiment was made to determine this, using a weighted projectile, but inasmuch as the weights of the ballistic projectiles were not exactly uniform, only an average weight was

used and the muzzle velocity observed at 25 feet from the muzzle was found to be 469.7 meters.

The increase of velocity after the projectile leaves the muzzle was observed in former experiments to be as much as ten or twelve meters, and we would be justified in assuming that the true muzzle velocity is nearer 457 meters than 469.7. It is evident that there is much uncertainty as to the exact value of the true muzzle velocity, as under the same conditions of service charge the velocities were observed to vary considerably, from 557 to 585 meters per second. It appears that the calculated velocities are therefore fairly coincident with the probable muzzle velocity.

In a similar manner a parabola has been fitted to the observations in shot 5 and is represented in Figure 14.

To obtain an idea of the appearance of a record for interior as compared with exterior ballistics, refer to Figures 15 and 16 for interior and 17 for exterior. Figure 15 is the record of shot No. 4 and 16 that of shot No. 9. The intervals between the screens for the exterior record were about ten feet.

CONCLUSION.

When the two objects of these experiments mentioned in the beginning of this paper are kept in view, namely; first, to improve the instrument, and second, to obtain measurements of the motion of projectiles through the bore without mutilating the gun in any way, it may be said that the two vital parts of the instrument have each been improved, These parts are the chronograph and tuning fork records, upon which the measurements are made. The intensity of the light for the chronograph record has been increased as described by the use of lenses, so that it is even more quick in its response to breaks in the electric current than formerly. This becomes a more important matter where the measurement is upon projectiles inside the bore than it was for exterior ballistics, because the time intervals to be measured are generally much shorter in the former case.

The improvements in the tuning fork records are more noticeable in the photographs than those in the chronograph records. The photographs, examples of which are shown in figs. 2, 3 and 4, are easily obtained and have the wave-lengths so clearly defined that there is little to be desired in point of accuracy. These records are interesting from a purely physical point of view, and when it is understood how easily they may be obtained, it seems certain they must find a place in laboratory investigations where

former methods left so much uncertainty as to the exact location of the maximum points of the waves.

Naturally many radical changes in the camera formerly used were suggested, such as the employment of sensitized films wrapped upon a cylinder instead of a plane glass plate; and such as a form of instrument in which the plate is stationary while the beam of light revolves. The process of developing and subsequently drying a film is too liable to cause change of shape which renders its use wholly unsuited for such accurate measurements as are involved. The first instrument required the sensitive plate to be mounted like a circular saw upon its shaft, requiring a hole in the negative itself. The new instrument will permit the use of ordinary commercial plates mounted in plate holders so that the plate and holder revolve together. Allowance is made for the varying thickness of the glass, and consequent eccentricity of the center of gravity, by mounting the whole in a comparatively heavy well balanced fly wheel.

It should be said that the original camera is the only one which has as yet been used in the experiments already described. A new instrument is now almost completed, being manufactured by the well known optician and instrument maker, J. A. Brashear of Allegheny, Pa., U.S.A. A special form of instrument to accompany the chronograph for the purpose of accurately measuring the angles obtained on the negatives, is in the hands of Messrs. Warner & Swasey of Cleveland, Ohio, U. S. A., the well known makers of astrŏnomical instruments. It is expected that these instruments will be installed at the U. S. Artillery School, Fort Monroe, Va., and be ready for use during the coming summer.

As to the second object mentioned above, it may be said that as many as seven observations of the projectile were taken in a distance of 57 cms. (only 1 foot 10½ inches) somewhat less than one-third the whole travel of the projectile, which is 184.4 cms. The shortest distance between observations was 3.8 cms. (about 1½ inch). The greatest distance observed along the bore was about 76 cms. (2½ feet), No attempt was made to remove what is thought to be the cause of the breaking of the rod, and with it the limitation to the distance measured along the bore, on account of lack of time to do more than obtain the results mentioned. It is thought however that these observations can be extended still further along the bore than they have as yet been observed.

An important point to be kept in mind is that the method used permitted a single mechanic working all day to prepare all the

material used for a single round, so that for more than a week consecutively, one shot was fired per day. This, moreover, was under experimental conditions, which obviously required more time than it would to do the same thing under other conditions; for example, the distances on the rod between the copper bands of the succeeding shot were not determined until the preceeding shot had been fired and the negative examined. It would be perfectly feasible to keep these rods already prepared for the special use of taking interior velocities. In that case the operation of observing a projectile inside the bore is almost as easily performed as observing it outside.

Although what has been said in this paper applies more particularly to the experiments with a 3.2-inch field rifle, it is not to be inferred in consequence that there is no application to guns of larger caliber. On the contrary, there is much reason to believe that experiments upon big guns, though the preparation for each shot may require a larger plant and take more time, will be even more successful than with a 3.2-inch rifle. The first part of the travel is unquestionably an important one to know something about, and, for an equal distance in the two guns, the velocity of the projectile may be much slower in the big gun. Even though the observations could not be extended throughout the entire bore, it would be a particular advantage to measure the first part of the motion.

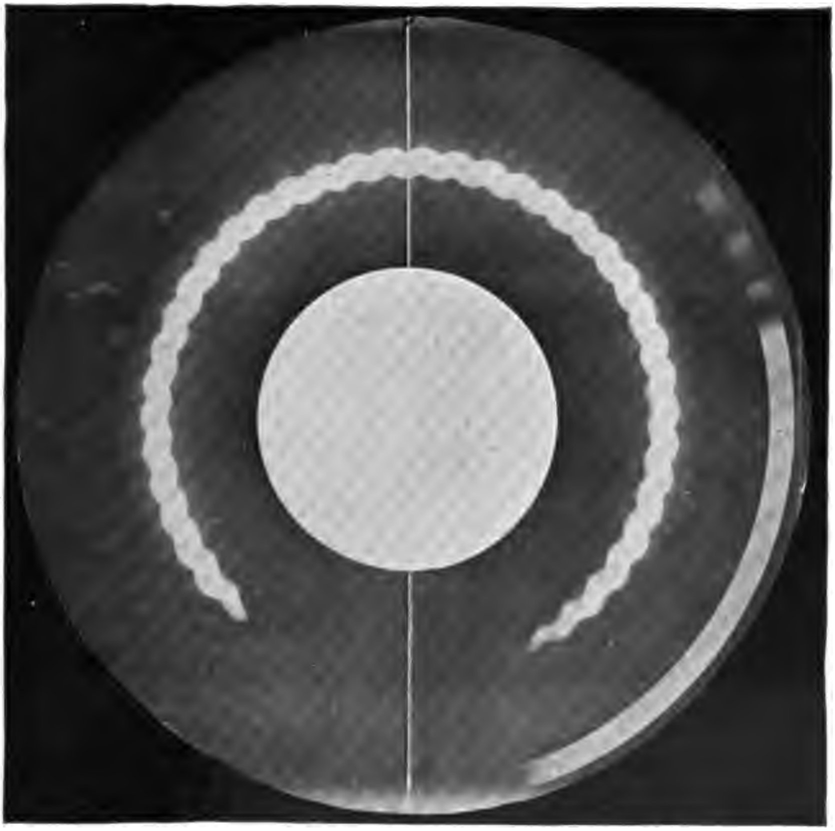

FIGURE 15.

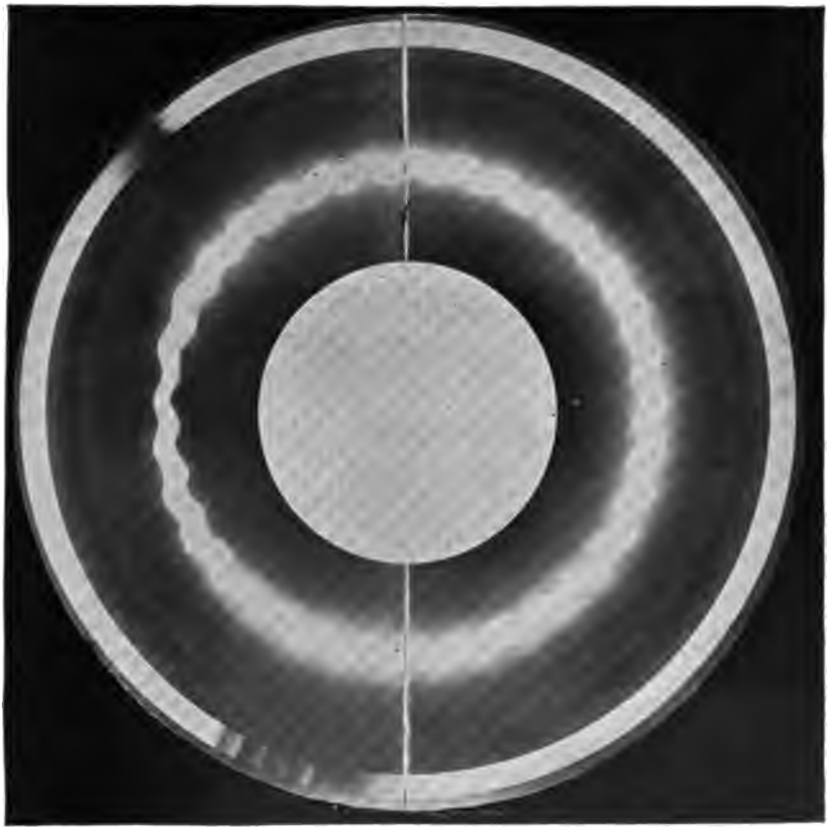

FIGURE 16.

Figure 17.

THE RESISTANCE OF AIR TO THE MOTION OF PROJECTILES.

Translated from the Italian in the Rivista di Artiglieria e Genio, January, 1896.

SECTION ONE.

During the past fifteen years there have appeared several treatises and pamphlets on ballistics, which resemble one another to the extent of following the method of the four functions introduced by us in 1880, but which are not all agreed in regard to the expressions for the resistance of the air adopted for the numerical calculation of these four functions. We made use of the Russian and English experiments (Mayevski and Bashforth); that is to say, of the formulas laid down by Mayevski in his treatise of 1872, modifying them slightly. Mitcham (West Point 1881), Ingalls (Fort Monroe, Va., 1883), De la Llave (Madrid 1883), Pouchelon (Paris 1885), Duran y Loriga (Corunna 1882), Ollero (Madrid 1890), and Holmberg (Stockholm 1895), adopted the same formulas. But Ingalls afterwards (1889) employed formulas based exclusively upon the experiments of Bashforth; and Greenhill and Hadcock (Woolwich 1887) also made use exclusively of these experiments. Hojel the distinguished and lamented author of the Dutch experiments, naturally employed the formulas devised by himself (Amsterdam 1883),—formulas which were afterward adopted by De la Llave (1893), and by Valliers (Paris 1894). Mayevski (Essen 1883 and Berlin 1886), laid down and used new formulas deduced from the Meppen firings, and was followed by Madsen (Copenhagen 1888), and by Zabouski (St. Petersburg 1895).

This diversity is easily explained by the different degrees of confidence reposed by the various authors in the experiments. It is true that in adopting the English and Russian experiments (1880), we experienced no embarrasment in making a selection. And afterwards, although sorely tempted by Hojel's experiments, which are indeed excellent both as regards the number of shots employed (about 1400) and the accuracy with which they were computed, we nevertheless adhered to the old formulas, although abandoned, perhaps unjustly by Mayevski himself; this because we satisfied ourselves that with the aid of the usual coefficient of

form, the results obtained by the various formulas would be substantially identical, the slight differences being explained by the discrepancies incident to all experiments, and especially to those upon the resistance of the air, although conducted by skilful and conscientious officers.

And so while we have often attempted to unite the results of all the experiments in a single formula, we have either not succeeded, or succeeded imperfectly; perhaps because, following the old methods, before studying the real resistance we studied its relation to the square of the velocity.

Major Chapel investigated instead the resistance itself, and drew therefrom the very important conclusion that for velocities above 300 meters the resistance is a linear function of the velocity; a conclusion important not only in itself but also in the subject of ballistics, in that it provides a new method for the general representation of the resistance.* Chapel's law having been confirmed, it was but natural to endeavor to ascertain whether the resistance for all velocities, great and small, could be represented by an hyperbola, the simplest of the asymptotic curves. An attempt was at once made by Captain Gilbert of the French marine artilley, but having imposed the condition that the hyperbola should be tangent to the axis of velocities, his formula is not sufficiently approximate for practical application.†

It is true that in the method of the four functions a single formula is not necessary; indeed there is no need of any formula at all, since the numerical values of the four functions can be taken from a simple table giving the experimental values of the resistance pertaining to different velocities,—a fact which we ourselves pointed out, and which was afterward made use of by Greenhill and Hadcock and by the Krupp Company. But this means simply that henceforth the law of resistance may be sought with but a single end in view, viz: that of obtaining values which would be the same as those given by experiments, and without considering at all whether such a formula introduced into the differential equations of ballistics renders them integrable or not. Such a research will however always be important, as is any research concerning a physical law. It will be especially important in ballistics since the more exact the values of the resistance, the more exact the applications of our method will

* The conclusion of Chapel, as shown by documents, dates from 1875, but only came to our knowledge through a communication addressed by Chapel to the Academy of Sciences at Paris. (*Comptes Rendus*, December 10, 1884).

† Major Vallier in one of his manuals, after giving Gilbert's formula, adds: "mais outre que cette représentation ne serait pas suffisamment approchée pour les applications, l'équation d'une telle courbe ne se prêterait pas au calcul; on est par suite forcé de renoncer à une formule unique pour l'expression de la loi."

This conclusion does not appear to us to follow rigorously from either of the two premises.

become; and perseverance is now an essential requisite for accuracy.

All the experiments referred to may be divided into three groups: the Russian and English (Mayevski and Bashforth), the Dutch (Hojel), and the Meppen firings (the Krupp Company). We have taken as a starting point the first group; and in the general equation of a conic section passing through the origin, the co-ordinates being velocity and resistance, we have so determined the four coefficients as to cause the curve to pass through four carefully selected experimental points of this same group. The result proved to be an hyperbola passing among the experimental points almost exactly as does the discontinuous curve represented by the five well known monomial formulas pertaining to the group, and which formulas contain, be it noted, ten arbitrary parameters (coefficients and exponents) instead of the four of the hyperbola. Naturally we did not stop with the first hyperbola, but tried many, selecting the four points in many different ways.

Among all these hyperbolas we have selected one which better than all the others represents the Russian and English experiments; and this is the one which we propose later. Indeed, the same hyperbola represents equally well, and perhaps even better, the Dutch group, and also the Meppen group up to the highest velocities, provided we multiply the ordinates of the curve, that is the resistances, by a constant coefficient viz: 0.896. This may be considered to be the mean coefficient of form of the projectiles of the second and third groups, that of the first group being unity. The asymptote of the hyperbola representing the last two groups approaches very closely the right line proposed by Chapel for representing the resistance of these same groups when the velocities were upward of 300 meters; and if the asymptote is not *precisely* the same right line, it is, we think, because the resistance is not properly represented by a right line, but by an hyperbola.

This hyperbola gives rise to an irrational expression for the resistance (irrational, be it understood, in the algebraic sense), but which, when introduced into the differential expressions for the four ballistic functions, D, J, A, T renders three of them integrable in elementary algebraic and logarithmic terms, and gives rise in the fourth to a higher logarithmic function, the numerical values of which may nevertheless be readily obtained from those of J and D, as we have shown in our Exterior Ballistics, page 66.

But the method of the four functions is not the complete solution of the ballistic problem, though in the great majority of practical cases it is quite sufficient. For the complete solution we must also know the values of a function β, which are always nearly unity, and which we have shown can be developed according to the descending powers of the ballistic coefficient. Of this series it is sufficient for the present to take the first term, and we have given elsewhere the general and explicit expression for it under the form of quadratures. Now the resistance given by the hyperbola gives rise in the function β to elliptic integrals of the three classes. We have a perfect theory of these integrals, but yet are unable to make much use of them in practice, because there have not yet been constructed for them sufficient numerical tables, analogous to the logarithmic and trigonometric tables.

But fortunately, due to an analytical fact of the greatest simplicity, our hyperbola can be divided into two other twin hyperbolas, which give the resistance almost as well as the original; one, however, gives it for the lowest velocities up to about 280 meters, and the other from that point upward; and this number is not empirical in its nature, but one which is derived naturally from that same analytical fact. The two twin hyperbolas are tangent to the parent curve and also to each other, having a contact of the second order; that is to say, a common osculatory circle always at that point. Now the equations of the two twin hyperbolas are rational and exceedingly simple, and render therefore very easy the construction, with elementary functions, of a table of the function β, analogous to the Table VI inserted in the French edition of our ballistics.

SECTION TWO.

The Proposed Hyperbola.

Denoting by r the resistance for unit of mass or the retardation, and by v the velocity (both in meters), the formula which we propose is as follows:

$$(1)\quad r = \frac{\delta i}{C}\left[0.1925v - 48.11 + \sqrt{(0.1725v - 4789)^2 + 21.12}\right],$$

where δ is the weight in kilogrammes of a cubic meter of air divided by 1.206; i is the coefficient of form of the projectile, and C its ballistic coefficient given by $C = \frac{p}{1000\,a^2}$, where a and p are the diameter and weight of the projectile in meters and kilogrammes respectively. Evidently this becomes unity for a projectile of 10 cm. and 10 kg.

Equation (1) may also be written

$$\left(r \times \frac{C}{\delta i} - 0.365v + 96\right)\left(r \times \frac{C}{\delta i} - 0.02v + 0.22\right) = 96 \times 0.22,$$

whence it is seen that the asymptotes of the hyperbola are,

$$r = \frac{\delta i}{C}\left(0.365v - 96\right), \quad r = \frac{\delta i}{C}\left(0.02v - 0.22\right).$$

Values deduced from equation 1.

v	$\frac{Cr}{\delta i}$		v	$\frac{Cr}{\delta i}$		v	$\frac{Cr}{\delta i}$		v	$\frac{Cr}{\delta i}$		v	$\frac{Cr}{\delta i}$	
m	m		m	m		m	m		m	m		m	m	
100	2.12		200	4.55		300	15.64		400	50.49		500	86.77	
		0.22			0.30			3.16			3.62			18.20
110	2.34		210	4.85		310	18.80		410	54.11		550	104.97	
		0.23			0.34			3.32			3.62			18.22
120	2.57		220	5.19		320	22.12		420	57.73		600	123.19	
		0.22			0.38			3.44			3.62			18.22
130	2.79		230	5.57		330	25.56		430	61.35		650	141.41	
		0.23			0.47			3.48			3.63			18.23
140	3.02		240	6.04		340	29.04		440	64.98		700	159.64	
		0.23			0.60			3.52			3.62			18.24
150	3.25		250	6.64		350	32.57		450	68.60		750	177.88	
		0.24			0.81			3.56			3.63			18.24
160	3.49		260	7.45		360	36.12		460	72 23		800	196.12	
		0.25			1.20			3.58			3.64			18.24
170	3.74		270	8.65		370	39.70		470	75.87		850	214.36	
		0.26			1.76			3.59			3.63			18.24
180	4.00		280	10.41		380	43.29		480	79.50		900	232.60	
		0.26			2.37			3.60			3.64			18.25
190	4.26		290	12.78		390	46.89		490	83.14		950	250.85	
		0.29			2.86			3.60			3.63			18.24
200	4.55		300	15.64		400	50.49		500	86.77		1000	269.09	

These values represent the retardation when $\frac{C}{\delta i} = 1$, and hence for a projectile of 10 cm. and 10 kg., whose coefficient $i = 1$, in an atmosphere of mean density. They represent also approximately the resistance encountered by the same projectile in kgs., and exactly in megadynes. (The megadyne is the force which applied to a body of 1 kg. gives it an acceleration of 10 meters.)

By comparing this hyperbola with the experiments we shall see to what degree of approximation it represents them.

But meanwhile it might be argued that the resistance *given by the hyperbola* for low velocities increases only a little more rapidly than the velocity itself, while it is generally admitted that for low velocities the resistance follows the theoretical law of Newton, *i. e.*, increases as the square of the velocity. To such a remark we would reply that the law of Newton, which by the way has not a very solid theoretical foundation, has been verified only for

extremely low velocities, *i. e.*, for velocities which have nothing to do with even the slowest of projectiles. Indeed it can not be shown from the experiments of Bashforth, of Mayevski, of Hojel, or from the Meppen firings, that the resistance for low velocities of projectiles follows the quadratic law. We do not wish by this, however, to set aside the law of the square, much less to replace it by the linear law. We are content that the formula for low velocities reproduces the numerical values of the resistance with sufficient accuracy for application to actual firing.

SECTION THREE.

The Russian and English Experiments.

The results of the Russian and English experiments are summed up by Mayevski in the following form, to which we have added the column Cr. The quantity ρ' represents, in an atmosphere of mean density ($\delta = 1$), the resistance in kg. divided by the area of the projectile's cross-section and by the square of the velocity. We have therefore

$$\rho' = r \times \frac{p}{g} \times \frac{4}{\pi a^2} \times \frac{1}{v^2} = \frac{Cr}{v^2}\,\frac{4000}{\pi g},$$

whence

$$Cr = \rho' \times \frac{v^2}{1000} \times \frac{\pi g}{4}.$$

By means of this equation were calculated the values of Cr in the table.

Values deduced from equation (1).

Caliber of piece.	v	ρ'	$Cr.$	Caliber of piece.	v	ρ'	$Cr.$
4-p'der. Russian.	172	0.0151	3.4	203 mm. Russian.	329	0.0338	28.1
203 mm. "	207	0.0137	4.5	203 mm. English.	332	0.0327	27.8
4-p'der. "	239	0.0148	6.5	229 mm. "	334	0.0332	28.6
12-p'der. "	247	0.0170	8.0	4-p'der. Russian.	337	0.0341	29.9
24-p'der. "	266	0.0160	11.3	178 mm. English.	340	0.0334	29.7
203 mm. "	282	0.0163	10.0	203 mm. "	345	0.0354	32.5
203 mm. English.	287	0.0184	11.7	229 mm. "	355	0.0364	35.3
229 mm. "	291	0.0247	16.1	178 mm. "	358	0.0382	37.7
203 mm. "	300	0.0230	15.9	203 mm. Russian.	360	0.0384	38.4
178 mm. "	302	0.0218	15.3	203 mm. English.	360	0.0393	39.2
12-p'der. Russian.	304	0.0221	15.7	4-p'der. Russian.	401	0.0450	55.6
4-p'der. "	307	0.0158	11.2	203 mm. "	409	0.0430	55.4
229 mm. English.	316	0.0305	23.5	203 mm. English.	419	0.0433	58.5
4-p'der. Russian.	317	0.0259	12.7	229 mm. "	420	0.0427	58.0
203 mm. "	319	0.0174	13.6	203 mm. "	460	0.0449	73.2
203 mm. English.	320	0.0277	21.8	203 mm. "	508	0.0440	87.5
24-p'der. Russian.	320	0.0299	23.6	178 mm. "	512	0.0443	89.4
178 mm. English.	322	0.0270	21.6				

In figure 1, are plotted the experimental points Cr, along with

the hyperbola given by [1] making therein $i = \delta = 1$, and in connection also with the discontinuous curve represented by the well known monomial formulas :

$$r = \frac{\delta}{C} \, 0.0^3 108 v^2, \qquad v < 240$$

$$r = \frac{\delta}{C} \, 0.0^6 449 v^3, \qquad 240 < v < 280$$

$$r = \frac{\delta}{C} \, 0.0^{13} 2 \quad v^6, \qquad 280 < v < 343$$

$$r = \frac{\delta}{C} \, 0.0^6 808 v^3, \qquad 343 < v < 420$$

$$r = \frac{\delta}{C} \, 0.0^3 339 v^2, \qquad v > 420$$

SECTION FOUR.

The Dutch Experiments:

The projectiles used varied from 8 to 40 cm. in caliber, but were all of modern form and nearly similar (radius of ogive varying from 1.99 to 2.03 calibers ; length of ogive from 1.31 to 1.33 calibers ; total length 2.8 calibers, with some 2.5, 3, and 4 calibers). Colonel Hojel in investigating the relation between resistance and velocity departed from the old method, which consists in comparing velocities with values of ρ'. Instead of this he considered certain functions of the velocity, $F(v)$, which arise by placing the resistance per unit of mass, *i. e.*, the retardation, under the form,

$$[a] \qquad r = \delta \frac{a^2}{4p} F(v) v = \frac{\delta}{C} \, \frac{F(v) v}{4000}.$$

He then calculated the values of $F(v)$ for 137 *mean* observations corresponding to velocities ranging from 138 to 660 meters, each *mean* observation being derived from a series of usually not less than 10 shots fired on the same day under similar circumstances, and with the effect of the wind duly considered. Calling v_1 and v_2 the velocities of a shot at points separated by a distance x, and denoting the velocity of the wind parallel to the plane of fire by ω, he calculated the retardation by the formula,

$$r = \frac{v_1^2 - v_2^2}{2x}$$

and properly assigned this value not to the mean velocity $\frac{v_1 + v_2}{2}$ but to $\frac{v_1 + v_2}{2} \pm \omega$, according as the wind was blowing against or with the motion of the projectile.

He then divided his observations into 11 groups; for each group he determined by the method of least squares the coefficients, *a*, *b*, *c*, of the equation,

$$F(v) = a + bv + cv^2,$$

and with the 11 equations in connection with velocities of 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650 meters, obtained the following corresponding values of $F(v)$: 74, 80, 142, 183, 341, 475, 560, 617, 662, 751, 762.

If now with these values we obtain from [*a*] the values of $\frac{Cr}{\delta}$, and if we also take from the table of section two the values of $\frac{Cr}{\delta i}$ given by (1), we may write out the following table in which the second column shows the number, *n*, of mean observations employed in each case.

Limits of the mean velocities in each group.	*n*	Probable values. for v	of $F(v)$	of $\frac{Cr}{\delta}$	$\frac{Cr}{\delta i}$ Hyperbola (1)
138 — 174	6	150	74	2.775	3.254
174 — 230	9	200	80	4.000	4.547
230 — 262	19	250	142	8.875	6.635
262 — 335	11	300	183	13.725	15.642
335 — 373	28	350	341	28.837	32.569
373 — 438	10	400	475	47.500	50.494
438 — 476	22	450	560	63.000	68.603
476 — 526	16	500	617	77.125	86.774
526 — 619	7	550	662	91.025	104.974
619 — 630	4	600	751	112.650	123.190
630 — 660	5	650	762	123.825	141.414

By dividing the numbers in the penultimate column by those in the last, and taking the mean of the results, we would obtain a mean value of the coefficient of form, i; but we have preferred, for greater accuracy, to employ least squares, taking into consideration the number *n*. Representing by ρ_h the numbers in the former, by ρ_c those in the latter column, and by i the required value of the coefficient of form, the sum of the squares of the errors is

$$S = \Sigma n (\rho_h - i\rho_c)^2$$

The value of i which renders this a minimum is given by

$$\frac{dS}{di} = o = \Sigma n (\rho_h \rho_c - i\rho_c^2),$$

whence we have

$$i = \frac{\Sigma n \rho_h \rho_c}{\Sigma n \rho_c^2}.$$

Since $\Sigma n\rho_h\rho_0 = 466827.99$, and $\Sigma n\rho_0^2 = 520820.23$, we have,

$$i = 0.89633.$$

We have adopted 0.896 for short; the equation of our hyperbola as given by the Dutch experiments (and also by the Meppen firings as we shall see), is therefore,

$$[1]_1\quad r = \frac{\delta}{C}[0.17248\,v - 43.107] + \sqrt{(0.15456\,v - 42.909)^2 + 17.0312}.$$

The formulas of Hojel are given below $[H]$; and in the table immediately following $[H]$, are found the values of $\frac{Cr}{\delta}$ given by hyberbola $[1]_1$ in connection with the experimental values and those given by $[H]$.

$$[H]\left\{\begin{array}{lll} \frac{Cr}{\delta} = 0.0^2 84535\,v^{2.5} & & \text{from } v = 140 \text{ to } v = 300 \text{ meters} \\ \frac{Cr}{\delta} = 0.0^8 54230\,v^5 & & \text{from } v = 300 \text{ to } v = 350 \text{ meters} \\ \frac{Cr}{\delta} = 0.0^5 51381\,v^{3.83} & & \text{from } v = 350 \text{ to } v = 400 \text{ meters} \\ \frac{Cr}{\delta} = 0.07483 & v^{2.28} & \text{from } v = 400 \text{ to } v = 500 \text{ meters} \\ \frac{Cr}{\delta} = 0.5467 & v^{1.91} & \text{from } v = 500 \text{ to } v = 700 \text{ meters} \end{array}\right.$$

v	$\frac{Cr}{\delta}$			Differs from experimental value.		n
	Experimental.	Hojel's Formulas.	Hyperbola $(1)_1$	Hojel.	Hyperbola $(1)_1$	
150	2.775	2.330	2.918	+0.445	—0.143	6
200	4.000	4.782	4.079	—0.782	—0.079	9
250	8.875	8.354	5.957	+0.521	+2.918	19
300	13.725	13.178	14.030	+0.547	—0.305	11
350	29.8375	28.4826	29.189	+1.355	+0.649	28
400	47.500	47.497	45.259	+0.003	+2.241	10
450	63.000	61.764	61.472	+1.236	+1.528	22
500	77.125	78.123	77.751	—0.998	—0.626	16
550	91.025	93.722	94.060	—2.697	—3.035	7
600	112.650	110.667	110.381	+1.983	+2.269	4
650	123.575	128.948	126.710	+5.373	—3.135	5

In figure 2 is plotted the hyperbola ($i = 0.896$) in connection with the discontinuous curve given by $[H]$, and the 11 experimental points.

If we calculate the mean error corresponding to the hyperbola ($i = 0.896$), we find

$$\sqrt{\frac{\Sigma n\,(\rho_h - i\rho_c)^2}{\Sigma n}} = \sqrt{\frac{\Sigma n\rho_h^2 - i^2\,\Sigma n\rho_c^2}{\Sigma n}} = 1.751,$$

while the mean error corresponding to the discontinuous line is somewhat smaller, 1.432, but only slightly so; it is rather surprising that the difference should be so slight when we remember that in reducing the hyperbola we could make use of only a single coefficient, i, (since the hyperbola was not determined by the aid of the Dutch experiments), while Hojel in establishing his formulas had at his disposition 10 parameters, (coefficients and exponents).*

With one parameter more Hojel could have obtained a continuous rational curve passing exactly through the eleven experimental points. But not on that account would such a curve have been exact, nor even could it be said to be more approximate than the discontinuous curve. For this reason we regard as preferable the hyperbola just determined, which although having a slightly greater mean error, is continuous.†

SECTION FIVE.

The Meppen Firings.

The Meppen firings cannot properly be called experiments undertaken for determining the laws of the resistance of the air. They had evidently more practical aims, aud one of these must have been the search for the dimensions or the form of the projectile which suffered the least loss of velocity. This seems to be rendered quite probable by the dates of the firings recorded in the tables of the Krupp establishment (extending from November, 1875 to December, 1886), and also by the fact that the velocities employed are comprised for the most part between 400 and 500 meters; while with velocities between 200 and 300 meters, where the law is more obscure and difficult to get at, the firings are very few. With velocities above 600 meters we find only three firings.

* If the four velocities selected at the point of division in table [*H*], (300, 350, 400, 500 meters), were really fixed, the parameters would be only 6, because among the 10 parameters there would exist 4 conditions. But since the 4 velocities referred to are themselves arbitrary, the arbitrary parameters are really 10 in number.

† A great part of the mean error of the hyperbola is due to the experimental point corresponding to the velocity 250 meters and resistance 8.875, a resistance greater than that given by all other known experiments. Hojel, in order to approach this point with his broken line, was compelled to depart sensibly from the two preceding, and also to tolerate an enormous discontinuity at the velocity 300 meters. If we exclude this point, the mean error of the hyperbola falls to 1.468, while that of the discontinuous curve rises to 1.528. Another hyperbola, viz:

$$r = \frac{\delta}{C}\left[0.1717\,v - 41.71 + \sqrt{(0.1496\,v - 41.52)^2 + 15.8037}\right]$$

gives a mean error of 1.435, almost exactly equal to that (1.432) of Hojel's discontinuous curve. Nevertheless we prefer the hyperbola $[1]_1$, because the other gives resistances a little large for velocities below 200 meters.

It is not stated in the tables whether the recorded firings represent isolated shots or groups. There are two circumstances which lead us to believe that they are to be treated as isolated shots; first, the absence of any indication to the contrary, and secondly the fact that we find firings recorded as distinct, which were executed on the same day, with the same gun, the same projectile, the same density of air, the same interval, and with almost the same velocities,—firings which would have to constitute a group if the recorded firings represented groups of shots.

The tables published by the Krupp establishment, at least those which we have at hand, are two in number; the first bears the date "Essen 1881", and the title "Table de Krupp pour le calcul des vitesses restantes horizontales et les durées de trajet des projectiles oblongs"; to this is added a leaflet with the title "Annexe à la table de Krupp pour le calcul, etc.," containing records of 37 shots with dates which extend from November 16, 1875 to October 4, 1881. These 37 shots are the ones given in the table farther on.

The other table is entitled "Die Berechnung der Schusstafeln seitens der Gusstahlfabrik Fried. Krupp", and according to a growing fashion, does not bear the date of the publication, but, from the date "17-12-86", of the last shot recorded, it is thought to have been published since 1886. We will call it *the second Krupp table.*

The first table, that of 1881, in addition to the columns relative to the remaining velocity and time of flight, has in the first column the "resistance of the air per square centimeter of cross section of the projectile", and extends from the velocity of 699 meters to 140. Upon this column were based the last formulas of Mayevski, as he himself states.

These are in our own notation, as follows:

$$[M]\quad \begin{cases} r = \dfrac{\delta}{C} 0.0^3\,1080\, v^2 & \text{for } v < 240; \\ r = \dfrac{\delta}{C} 0.0^6\,450\quad v^3, & \text{from } v = 240 \text{ to } v = 295; \\ r = \dfrac{\delta}{C} 0.0^{11}517\quad v^5, & \text{from } v = 295 \text{ to } v = 375; \\ r = \dfrac{\delta}{C} 0.0^6\,725\quad v^3, & \text{from } v = 375 \text{ to } v = 419: \\ r = \dfrac{\delta}{C} 0.0^3\,3039\, v^2, & \text{from } v = 419 \text{ to } v = 700. \end{cases}$$

But what basis has the column of resistances in the Krupp

table of 1881? Mayevski is silent on the subject. neither do we find in the Krupp table itself any explicit statement. After intimating how, given the resistance, a table of remaining velocities and time of flight may be constructed, they go on to say, "Such a table for differences of velocity of 10 meters was made out at the Krupp works at the commencement of 1880. The remaining velocities calculated by this table agree very well with the velocities measured at Meppen and elsewhere. For greater convenience of calculation, the table was changed so that the intervals of velocity would be one meter, and at the same time it was corrected by the results of experiments".

But it should be noted that the "table" spoken of refers only to the columns of remaining velocities and times of flight. It may therefore be supposed that the column of resistances was originally a table deduced from the Russian and English experiments, especially the English, somewhat modified at the beginning of 1880, and afterwards touched up in 1881 by adapting it to the projectiles of the establishment.

Indeed the firings previous to 1880 recorded in the before-mentioned "annexe" are only 22 in number; adding those of 1880 and 1881, they amount to 37; and if we add also 15 other shots previous to 1882 not recorded in the "*annexe*" (we know not why), but recorded in the second Krupp table, we have a total of 52 shots; a total which as to number and especially as to distribution of the velocities employed, cannot serve to establish clearly a general law of resistance, (which by the way had already been established), although it may serve very well for the establishment of a coefficient of form.*

By this we do not wish to assert that the Krupp works did not previous to 1882 fire other shots than the 52 mentioned, but we do not believe that they were used in making the table of 1881. Can they have been excluded on account of imperfections discovered in them? If not, why employ some and not the others? Can we perchance believe that the shots given in the tables were mentioned solely to show the approximation which the tables give to the striking velocities as measured in the experiments? But every one knows that when we have a great number of shots, we can always find several suited to the verification of any law whatever.

Moreover, the results of Bashforth's and Mayevski's experiments had already been published. Why did not the Krupp

* The Russian and English experiments comprised more than 300 shots; the Dutch about 1400.

people make use of them? Mayevski, who executed his own, utilized also the English experiments, and did well in doing so; the Krupp firm would have done equally well to utitize experiments which were then known.

Mayevski, in order to show finally to what degree of exactness formulas [*M*] represent the resistance of the air, published the following table, which is the "annexe" in connection with the Krupp table of 1881, with the single difference that in place of the column of remaining velocities taken from that table, Mayevski inserts the remaining velocities deduced from the ballistic tables which were based upon formulas [*M*].

Day.	Month.	Year.	Caliber.	Kind of powder.*	Length in calibers.	Weight.	Weight of cubic cm. of air.	Distance between points where v' and v'' were measured.	Measured horizontal velocity.		Calculated horizontal velocity.	
									v'	v''	v''	$\Delta v''$
			m		*kg*	*kg*	*kg*	*m*	*m*	*m*	*m*	*m*
16	11	75	0.2400	G.o	2.8	125	1.245	1450.0	467.0	380.0	380.4	—0.4
—	—	—	—	G.p	—	161	—	—	454.5	390.0	388.0	+2.0
18	3	76	0.1726	—	—	61.5	1.226	1389.0	477.0	388.0	387.5	+0.5
24	—	—	—	—	—	—	—	1429.0	514.7	416.6	415.7	+0.9
2	—	—	0.1481	—	—	39.3	1.260	—	518.0	401.6	401.2	+0.4
3	—	—	—	—	2.5	33.5	1.240	—	507.7	380.0	379.5	+0.5
30	11	—	—	G.o	2.8	31.3	1.265	924.0	475.8	387.8	387.4	+0.4
2	7	78	0.3550	G.p	—	525.0	1.200	1884.0	495.9	432.7	432.3	+0.4
11	6	79	—	—	—	—	—	2384.0	490.0	415.0	412.3	+2.7
20	6	—	—	—	—	—	—	2389.0	488.5	409.6	410.7	—1.6
17	12	78	0.1491	G.o	—	31.3	1.265	1950.0	609.0	394.0	392.2	+1.8
7	8	79	—	G.p	4.0	51.0	1.206	1929.0	505.2	394.6	392.2	+2.4
9	8	78	0.1524	G.o	—	51.5	1.205	1450.0	472.4	391.3	388.5	+2.8
—	—	—	—	—	2.8	32.5	—	—	577.0	422.0	421.3	+0.7
13	12	—	0.1491	—	—	31.3	1.230	—	632.4	460.9	459.6	+1.3
25	6	79	0.2400	G.p	8.8	215.0	1.208	1904.0	480.4	412.8	411.3	+1.5
5	8	—	0.4000	—	2.8	777.0	1.180	7384.0	499.4	433.7	431.8	+1.9
6	—	—	—	G.o	—	643.0	1.190	—	533.4	443.8	446.6	—2.8
—	—	—	—	—	—	—	—	—	531.5	444.5	445.0	—0.5
6	10	76	0.0840	—	—	65.5	1.197	2447.0	446.9	266.0	269.0	—3.0
3	—	—	0.1200	—	—	16.4	1.211	—	463.3	284.1	289.2	—5.1
6	12	78	0.1491	—	—	31.3	1.285	3448.0	536.6	294.8	290.5	+4.3
22	1	80	0.1050	—	3.5	16.0	1.300	3436.0	481.5	282.0	277.4	+4.6
17	—	—	0.0960	—	—	12.0	1.340	3439.0	425.8	256.2	254.9	+1.3
26	6	—	0.1070	—	2.7	12.5	1.218	777.5	205.1	188.2	188.2	0.0
10	7	—	0.1524	—	2.8	31.5	1.206	966.5	203.0	188.0	188.0	0.0
11	—	81	0.1491	G.p	—	39.0	1.218	1429.0	470.0	369.5	369.4	+0.1
25	—	—	0.2830	—	2.5	234.7	1.205	1379.0	465.3	403.9	403.8	+0.1
26	—	—	—	—	—	—	1.200	1919.0	465.9	385.4	383.7	+1.7
—	—	—	—	—	—	—	—	2421.5	466.5	370.6	367.0	+3.6
27	—	—	—	—	—	—	1.220	2921.5	464.8	347.8	350.0	—2.2
28	—	—	—	—	—	—	1.227	3426.0	463.7	336.0	335.9	+0.1
29	—	—	—	—	—	—	1.220	4446.5	460.0	316.6	315.0	+1.6
1	8	—	—	—	—	—	1.192	5945.0	455.8	295.0	293.0	+2.0
4	—	—	—	—	—	—	1.206	—	453.1	294.7	291.4	+3.3

* G.O. = Ordinary Grain; G.P. = Perforated Grain.

It may be noted here that if we apply rigorously the rule laid down by Mayevski in the same memoir and also in the "Ballistische Formeln nach Siacci", for deducing remaining velocities by means of Didion's a, we obtain divergencies from the measured values which are sensibly greater. For example, applying this rule to the two last shots we find for the horizontal velocities these two numbers, 291.4 and 289.6 instead of 293.0 and 291.4; whence the differences are 3.6 and 5.1 instead of 2.0 and 3.3.

We make these observations, and rightly too as we think, because to the empirical formulas [M] and to the numbers upon which they are based is justly attached a high degree of confidence; and also in order to justify what we said in the beginning that Mayevski was perhaps wrong in abandoning his formulas of 1872. If he had adhered to the old formulas, he would have obtained with the aid of a coefficient of form, differences almost exactly equal to or perhaps even less than, those given by the new.

In the second table, *i. e.* in the one published by Krupp after 1886, the column of resistances is extended to velocities of 1000 meters on the one hand and to 50 meters on the other; and the values of the resistance from 699 meters downward are different from those given in the table of 1881. What foundation have these new numbers?

Annexed to the table is a record where, in addition to the firings before discussed, are shown many others previous to 1881. In these last firings is doubtless to be found the reason for the changes exhibited by the new table; but as regards values assigned to the resistance for velocities above 700 meters, we do not know upon what they are based, since among the recorded firings we do not find a single velocity which approaches 1000 meters. Moreover in the firings subsequent to 1881 the maximum velocity is only 595 meters, while among those of 1878 we find one with a velocity of 632.

It is true that we find a note on page 5 of Mayevski's memoir before referred to, wherein he says that Krupp has, with the 10.5 and 8.7 centimeter guns, obtained the respective velocities of 933 and 861 meters; also that the experiments show that the fifth of equations [M] can be extended from 419 to 900 meters. We can not reconcile this statement of the illustrious general, (who must have been aware of the experimental data), with the resistances given by the Krupp tables. For instance this latter for $v = 900$ assigns to every square cm. of cross-section a resistance of 2.745 kilogrammes, while Mayevski's formula gives 3.191.

Hence the 10.5 cm. projectile with a velocity of 900 meters would encounter according to Krupp a resistance of 238 kg., and according to Mayevski one of 276 kg.

However that may be, Colonel Zabouski, upon the basis of the Krupp table, has limited the application of the fifth of formulas [M] to 550 meters; and for velocities higher than that has added these:

$$[Z] \qquad \begin{cases} r = \dfrac{\delta}{C} 0.0^2 2017\, v^{1.70}, & 550 < v < 800 \\ r = \dfrac{\delta}{C} 0.0^2 5499\, v^{1.55}, & 800 < v < 1100 \end{cases}$$

In figure 3 is shown the discontinuous curve of the values of $\frac{Cr}{\delta}$ given by formulas [M] and [Z], (7 equations, 14 parameters), and also the hyperbola $[1]_1$, as given by the Dutch experiments. The divergencies are, as is seen, very small.

For velocities a little above 300 meters the hyperbola is not distinguishable from its asymptote, whose equation is

$$\frac{Cr}{\delta} = 0.327\, v - 86,$$

and which differs but little from the right line of Chapel, whose equation is

$$\frac{Cr}{\delta} = 0.3234\, v - 84.7^*.$$

For $v = 1000$, both the hyperbola $[1]_1$ and its asymptote give

$$\frac{Cr}{\delta} = 241.0.$$

The right line of Chapel gives

$$\frac{Cr}{\delta} = 238.7.$$

Zabouski's equations and the Krupp table give

$$\frac{Cr}{\delta} = 245.2 \text{ and } 245.5.$$

But these differences are of very little consequence, none in fact, till the relation existing between the original experimental data and Zabouski's formulas or Krupp's tables is well known.

* In the "*Rivista*" for December, 1894, the right line of Chapel is given by

$$R = 42\, v - 11000,$$

R being the resistance in kg. divided by the cross-section of the projectile in square meters. To reduce R to retardation r, or better to $\frac{Cr}{\delta}$, we must multiply by $\frac{\pi g}{4000}$, *i.e.* by about 0.0077.

It might happen that if the data should become known or other experiments be made, we would find that the true resistance for velocities approaching 1000 meters is a little less than that given by the formulas and tables referred to. Not only is it possible but it is even probable, since in passing from the first Krupp table to the second the resistance for $v = 700$ is diminished somewhat; so also in passing to a third table the resistance for $v = 1000$ might be found to require a diminution.

F. Siacci,

Colonel of Artillery, In the Reserve.

Naples, December 4th, 1895.

[*Translated by* First Lieutenant, F. S. Harlow, First Artillery].

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[*Transl*

RESISTANCE OF THE AIR FOR GREAT VELOCITIES OF PROJECTILES.

Translated from the Russian.

1. According to results obtained by experiments made in Russia by General Mayevsky, in England by Bashforth, and in Germany by the Krupp works, touching the resistance of the air to oblong projectiles, General Mayevski came to the conclusion that the resistance of air for velocities smaller than 240 meters and greater than 419 m., is proportional to the squares of the velocities, and that for velocities approximating the velocity of sound (340 m.), the resistance increases at a greater rate than the squares of the velocities.

In 1884 Hojel, Colonel of the Dutch artillery, came to the conclusion, based on results of experiments made in Holland and at the Krupp works, that the resistance of the air for velocities above 500 meters increases less rapidly than the squares of the velocities; according to his calculations the degree of increase is equal to 1.91 for velocities between 500 and 700 meters.

In 1890 the Krupp works issued tables in which are stated the amount of resistance of the air for successive velocities up to 1000 meters.

These data were obtained by the Krupp works by firing with guns of various calibers, and by determining the velocities of the projectile at two different points of the trajectory.

By an examination of these tables it may be concluded that for velocities greater than 550 meters the resistance increases less rapidly than the squares of the velocities. I have expressed this ratio of increase by 1.70 for velocities between 550 and 800 meters and by 1.55 for velocities between 800 and 1000 meters.

According to results of experiments published by the Krupp works in 1881, General Mayevsky deduced an expression for the resistance of the air as stated in 1882 in his *brochure* "Solution of problems in sighting and in slant firing."

In the above tables the resistance is given for velocities under 700 meters. The table cited in 1890 is a continuation of the preceding ones.

From the data given by the latter tables I have deduced an expression for the resistance of the air for velocities up to 1000 meters.

Combining them with the formulas given in 1882 by General Mayevsky, and taking the meter and kilogram as units, there results the following, within the limits of the velocities:

From $v = 1000$ to $v = 800$ meters, the resistance $\rho = 0.7130\,\pi\,R^2 \dfrac{d}{d_0} v^{1.56}$.

From $v = 800$ to $v = 550$ meters, the resistance $\rho = 0.2616\,\pi\,R^2 \dfrac{d}{d_0} v^{1.70}$.

From $v = 550$ to $v = 419$ meters, the resistance $\rho = 0.0394\,\pi\,R^2 \dfrac{d}{d_0} v^2$.

From $v = 419$ to $v = 375$ meters, the resistance $\rho = 0.0^4940\,\pi\,R^2 \dfrac{d}{d_0} v^3$.

From $v = 375$ to $v = 295$ meters, the resistance $\rho = 0.0^9670\,\pi\,R^2 \dfrac{d}{d_0} v^5$.

From $v = 295$ to $v = 240$ meters, the resistance $\rho = 0.0^4583\,\pi\,R^2 \dfrac{d}{d_0} v^3$.

From $v = 240$ meters to $v =$ small. Resistance $\rho = 0.0140\,\pi\,R^2 \dfrac{d}{d_0} v^2$.

in which R is the radius of the cylindrical part of the projectile, d the density of the air during the experiment, $d_0 = 1.206$ kilograms.

By the above it is seen that the resistance of the air for smaller velocities is in proportion to the squares of velocities, for velocities approximating those of sound the resistance increases considerably more rapidly than the squares of velocities, and for velocities greater than 550 meters, increases less rapidly than the squares of velocities.

If we consider the air as consisting of particles striking against each other, and possessing different velocities dependent upon size and direction conformably to the mechanical theory of gases, the average velocity of the advancing movement of the particles of gas at the temperature of melting ice will be equal to 485 meters, and at the temperature of 15° Celsius will be about 500 meters.

Thus the law of the increase of the resistance of air with the velocity of the projectiles, changes its character with velocities with which are associated certain characteristics of the air.

2. As I intend publishing in a new edition of exterior ballistics detailed tables for the solution of firing problems with velocities up to 1100 meters, calculated for the above formulas, I append herewith a short table of the value of the functions $D(u)$, $A(u)$, $I(u)$, $T(u)$, $B(u)$ and $M(u)$ corresponding to the values of u between 600 and 2000 meters. In working out the value of these

functions the resistance of the air is expressed by the formula

$$0.5091\ \pi\ R^2 \frac{a}{d_0}\ v^{1.6},$$

in which the resistances (for velocities from 600 to 1000 meters) are nearly similar to those published in the tables of the Krupp works in 1890.

This table and the ballistic tables prepared by Lieutenant Colonel Langenskjold may be used for the solution of problems of sighted firing with velocities not surpassing 1000 meters, but attention must be given to the signs of the functions. The functions given [with the exception of $I(u)$] reduce to zero for values of u each nearly equal to 700 meters. The functions $D(u)$, $A(u)$, $T(u)$ and $M(u)$ change their signs and become negative, while the function $B(u)$ having a double root keeps its positive value in passing through zero.

The values of u that reduce the above functions to zero are shown in the note to the tables.

3. Let us adopt the above table and the tables of Lieutenant Colonel Langenskjold for the solution of the two following problems:

Example I.—On the principal proving ground, during experimental firing on the 29th of February, 1894, with the 6-inch 50 caliber rapid firing gun of Canet, with a charge of 27½ pounds of Okhta smokeless powder, the velocities of the projectile were measured at the points of its trajectory as follows:

$x_1 =$ 89.6 meters (42 sagenes), average velocity $v_1 =$ 785.9 meters (2579 ft.).
$x_2 =$ 509.9 meters (239 sagenes), average velocity $v_2 =$ 745.2 meters (2445 ft.).

Since the coefficient λ enters the following formula* it must be determined:

$$C = \frac{P}{(2R)^2} \cdot \frac{d_0}{d} \cdot \frac{1}{\lambda} \frac{1}{1000}.$$

Moreover we have the weight of the projectile $P = 43.0$ kilograms (105 Russian pounds); the caliber $2R = 0.1524$ meters (6 inches).

The firing took place at a temperature of 7½ Celsius and at an atmospheric pressure of 757.4 mm.; therefore according to table of Appendix I, Exterior Ballistics, we find $\frac{d}{d_0} = 1.099$.

Representing by C_1 the value C for $\lambda = 1$, we obtain

$$\log C_1 = 0.2265.$$

In consequence of the small angle of departure (15′) we have

* Zabudsky. Exterior Ballistics, lithographed pamphlet, part II, page 10.

since $a \cos\theta = 1$, $a = 1$; therefore from Appendix 1, Exterior Ballistics, page 19, we may write,

$$\frac{x_2 - x_1}{C} = D(v_2) - D(v_1).$$

From the table we find

$$D(v_1) = -430.7,$$
$$D(v_2) = -238.0,$$
$$D(v_2) - D(v_1) = 192.7,$$

hence from the equation

$$\lambda = \frac{x_2 - x_1}{C_1 [D(v_2) - D(v_1)]}$$

we determine the coefficient

$$\lambda = 0.7723.$$

The projectiles used in the Canet gun have a longer head (about 1.75 calibers) than the projectiles for which the expression of the resistance of the air shown in No. I is found; the length of the head of *these* projectiles is about 1.3 caliber (the coefficient being $\lambda = 1$).

Example II.—To determine the tabular data for a projectile fired by the 6-inch Canet gun at a distance of $X = 2000$ sagenes (4,666 yards).

We have

$P = 43.0$ kilog. (105 Russian pounds); $2R = 0.1524$ meters (6 inches).

$$\frac{d}{d_0} = 1; \ \lambda = 0.7723.$$

Initial velocity $V = 792.5$ meters (2600 feet).

Using the formulas shown in Exterior Ballistics (Appendix I, page 46) and the tables of Lieutenant-Colonel Langenskjold we determine the necessary data.

We have

$$\log C = 0.3810.$$

By the formula

$$\sin 2\varphi_0 = \frac{gX}{V^2} \left\{ 1 + [\bar{9}.0728] \frac{V^2 X}{C} \right\}$$

we determine the angle of departure necessary for the determination by the table of the value of a;

$$\varphi_0 = 4^\circ\, 27';$$

by the table we find

$$a = 1.0010,$$

and deduce

$$U = a\, V \cos\varphi_0 = 790.9.$$

The value u, corresponding to the point of impact is obtained from the equation

$$D(u) = \frac{aX}{C} + D(U) = 1776 - 454 = 1322,$$

whence

$$u = 468.6.$$

We find by the above mentioned tables

$$A(U) = -26.04;\ I(U) = 0.04967;\ T(U) = -0.612;$$
$$B(U) = -0.276;\ M(U) = -0.00113;$$
$$A(u) = 133.62;\ I(u) = 0.14715;\ T(u) = 2.322;$$
$$B(u) = 3.9441.$$

By the formulas

$$\tan\varphi = \frac{Ca}{2}\left\{\frac{A(u) - A(U)}{D(n) - D(U)} - I(U)\right\},$$

$$\tan\theta_c = \frac{Ca}{2}\left\{I(u) - \frac{A(u) - A(U)}{D(u) - D(U)}\right\},$$

$$v = \frac{u}{a\cos\theta_c},$$

$$T = C\left\{T(u) - T(U)\right\}$$

and

$$Z = K\frac{d_0}{d}VX\left\{\frac{B(u) - B(U)}{D(u) - D(U)} - M(U)\right\},$$

$$\varphi = 2^\circ\,45',\ \theta = 3^\circ\,57',\ v_c = 469.2 \text{ meters (1540 feet)}$$

$$T = 7.05 \text{ seconds and } Z = 4.73 \text{ meters.}$$

In calculating the derivative Z the coefficient K is found from the formula

$$K = \frac{\mu\pi}{\eta}\ \frac{x}{h}\ \frac{Cg}{1000}$$

in which $\mu = 0.55$, $\frac{x}{h} = 0.32$, and $\frac{\pi}{\eta} = \tan 6^\circ$, because the angle of the rifling at the muzzle of the 6-inch Canet gun is 6°.

The coefficient K, entering the derivative formula, must be determined by firing during fair weather. The coefficient K as usually found by experiment is almost 1½ times larger than the one calculated by means of the above formula.

BALLISTIC TABLES

For solving problems in firing for velocities greater than 600 meters.

u	$D(u)$		$A(u)$		$I(u)$		$T(u)$		$B(u)$		$M(u)$	
meters	—		—		+		—		+		—	
1000	1358		59.66		0.02711		1.629		1.947		0.00243	
		40		111		80		41		97		4
990	1318		58.85		0.02791		1.588		1.850		0.00239	
		41		115		82		41		96		5
980	1277		57.70		0.02873		1.547		1.754		0.00234	
		41		120		85		42		95		4
970	1236		56.50		0.02958		1.505		1.659		0.00230	
		42		124		87		43		94		5
960	1194		55.26		0.03045		1.462		1.565		0.00225	
		41		128		89		43		92		4
950	1153		53.98		0.03134		1.419		1.473		0.00221	
		42		133		92		44		91		5
940	1111		52.65		0.03226		1.375		1.382		0.00216	
		42		137		95		45		90		5
930	1069		51.28		0.03321		1.330		1.292		0.00211	
		42		143		97		46		88		6
920	1027		49.85		0.03418		1.284		1.204		0.00205	
		43		148		100		47		86		5
910	984		48.37		0.03518		1.237		1.118		0.00200	
		43		153		102		47		84		6
900	941		46.84		0.03620		1.190		1.034		0.00194	
		43		159		106		48		83		6
890	898		45.25		0.03726		1.142		0.951		0.00188	
		43		164		109		49		80		7
880	855		43.61		0.03835		1.093		0.871		0.00181	
		44		170		112		50		78		6
870	811		41.91		0.03947		1.043		0.793		0.00175	
		44		176		116		51		76		7
860	767		40.15		0.04063		0.992		0.717		0.00168	
		44		183		119		52		73		7
850	723		38.32		0.04182		0.940		0.644		0.00161	
		45		190		123		53		71		7
840	678		36.42		0.04305		0.887		0.573		0.00154	
		45		196		126		54		67		8
830	633		34.46		0.04431		0.833		0.506		0.00146	
		45		204		131		55		64		8
820	588		32.42		0.04562		0.778		0.442		0.00138	
		46		212		135		56		61		8
810	542		30.30		0.04697		0.722		0.381		0.00130	
		46		219		140		57		57		9
800	496		28.11		0.04837		0.665		0.324		0.00121	
		46		227		144		58		53		9
790	450		25.84		0.04981		0.607		0.271		0.00112	
		47		235		149		60		50		10
780	403		23.49		0.05130		0.547		0.221		0.00102	
		47		245		153		60		46		10
770	356		21.04		0.05283		0.487		0.175		0.00092	
		47		254		159		62		42		11
760	309		18.50		0.05442		0.425		0.133		0.00081	
		48		264		165		63		36		11
750	261		15.86		0.05607		0.362		0.097		0.00070	
		48		274		170		65		30		12
740	213		13.12		0.05777		0.297		0.067		0.00058	
		49		284		177		66		26		12
730	164		10.27		0.05954		0.231		0.041		0.00046	
		49		296		183		68		20		13
720	115		7.31		0.06137		0.163		0.021		0.00033	
		49		308		189		69		13		13
710	66		4.23		0.06326		0.094		0.008		0.00020	

u	$D(u)$	$A(u)$	$I(u)$	$T(u)$	$B(u)$	$M(u)$
meters	—	—	+	—	+	—
710	66	4.23	0.06326	0.094	0.008	0.00020
	50	320	197	70	6	14
700	16	1.03	0.06523	0.024	0.002	0.00096
	+ 50	+ 332	204	+ 72	1	+ 15
690	34	2.29	0.06727	0.048	0.003	0.00009
	51	346	212	74	9	16
680	85	5.75	0.06939	0.122	0.012	0.00025
	51	360	221	76	17	17
670	136	9.35	0.07160	0.198	0.029	0.00042
	51	376	229	78	26	17
660	187	13.11	0.07389	0.276	0.055	0.00059
	52	391	238	80	36	18
650	239	17.02	0.07627	0.356	0.091	0.00077
	53	407	248	81	46	20
640	292	21.09	0.07875	0.437	0.137	0.00097
	54	424	258	83	57	21
630	346	25.33	0.08133	0.520	0.194	0.00118
	53	443	269	86	69	22
620	399	29.76	0.08402	0.606	0.263	0.00140
	54	462	281	88	81	23
610	453	34.38	0.08683	0.694	0.344	0.00163
	54	481	293	90	96	25
600	507	39.19	0.08976	0.784	0.440	0.00188

$D(u) = 0$ for $u = 696.8$ meters.
$A(u) = 0$ for $u = 696.8$ meters.
$T(u) = 0$ for $u = 696.7$ meters.
$B(u) = 0$ for $u = 696.2$ meters.
$M(u) = 0$ for $u = 696.2$ meters.

N. Zabudski.

Translated by Captain Henry T. Allen, 2nd Cavalry.

SEA-COAST DEFENSES AND THE ORGANIZATION OF OUR SEA-COAST ARTILLERY FORCES.

DISCUSSION.

W. A. Simpson, *First Lieutenant, Second Artillery, U. S. Army*.—Colonel Sanger's paper is an excellent and a timely one. Upon the necessity for sea-coast defenses and a larger force of artillery all are agreed. The former we are in the way of getting. There seems to be some chance of a slight increase also in the artillery personnel, but as Colonel Sanger truly says, "* * * The army can never supply all the officers and men needed to man our sea-coast fortifications. It will be necessary to supplement the army, and we should know in time of peace under what plan these additional men are to be enrolled and how they are to be trained".

The question is,—"How should this artillery force be organized"? Admitting that whatever amount of regular artillery force that may be allowed by Congress will be insufficient, it follows that the auxiliary forces must be state troops of some kind, and the most practical plan would seem to be the organization along the sea-board of heavy artillery batteries, forming a part of the national guard of the states in which they exist, having a proper proportion of field officers, with the chiefs of artillery of the states as their heads, and entirely independent of other state organizations. Instead of going to state camps these organizations should have a tour of duty at the nearest forts equipped with modern ordnance and appliances, and receive all the assistance possible from the regular garrisons. The War Department would undoubtedly do everything in its power to foster such auxiliary forces, but something more than that would be needed. As the harbor of New York, for instance, is improved at national expense, on the ground that it is for the benefit of the whole country, so is its proper defense for the benefit of the whole country, which should therefore contribute towards the expenses of these state sea-coast artillery organizations, at least to the extent of paying for ammunition expended in target practice, and for the expenses (pay and rations), such as are incurred for ordinary state troops at their state camps, while tours of duty at the forts are being performed.

Legislation by Congress would be needed, and legislation should also fix the conditions to be met by the states, in order to receive the aid provided by the general government. Uniformity in organization and control would thus be obtained, while the instruction would be patterned as far as practicable on that of the regular artillery. It would then rest with the states to pass the necessary laws to enable them to comply with federal requirements.

I agree with Colonel Sanger on the advisability of the appointment of a commission, to make a comprehensive study of the whole question, and embody the results of their investigations in a report, to be used as the basis of a broad general federal law.

S. E. ALLEN, *First Lieutenant, Fifth Artillery, U. S. Army.*—To comment upon so excellent a paper as Colonel Sanger's is difficult. Many statements of facts contained in Part I are familiar to all army officers, as the author states, but they gain in force by his presentation. His arguments are clear and convincing, and serve admirably not only to show the importance of the question of providing for the service of our coming armament, but to direct the mind at once to the fundamental principles upon which its solution must rest. His ideas are the more valuable to us in that they are conceived from a point of view different from our own, and are based upon intimate acquaintance with the National Guard, the substantial business element and the legislative body of our most influential state.

In the introduction, the headings, "Need of recognized authority to decide military questions", and "Need of concensus of opinion on military questions", and in Part II, "Need of one general plan for the organization of all our sea-coast artillery", clearly state the "needs" which thoughtful men appreciate now, and which the early future will certainly emphasize. In Part II, the "statement of the problem is very complete". In the "statement of the principles which should govern the organization of our sea-coast artillery forces", the author has adhered strictly to enunciation of principles without confusion of detail. Some of these need no comment besides his own. Others demand a careful consideration, which may result in marked differences of opinion.

The logical order of precedure would be for Congress to promulgate a set of principles to govern all military organization, supplementing it by such legislation as to detail as may be

required. The military authorities, national and state, would complete the work enthusiastically.

It may be however that Congress will consider the situation sufficiently relieved by giving us a little of the *detail* without the *principle*. If so, to do ourselves justice, every energy must be bent to the immediate development of the new conditions as well as the remaining ones of the old, to perfect every detail of organization and training as far as the law will permit. Doubtless there will still be wanting important improvements in these, beyond our power to accomplish without additional legislation. It will be our duty then to investigate them and to urge well digested views upon Congress. Thus we may finally attain, by successive steps of a reversed process, the development of that homogeneous system of organization which in the beginning should have been outlined for us.

In the absence of progressive action by our law makers, artillery officers are not only free but are morally in duty bound to enter into the broadest field of investigation, to formulate a policy and work for its adoption.

Colonel Sanger has taken the initial step. His statement of principles is so complete as to merit repetition by quotation in full.

1. The sea-coast artillery arm of the army must be increased.

2. Auxiliary sea-coast artillery formations must be organized, because the regular army will never have enough artillerymen to serve our sea-coast guns in time of war. These auxiliary forces should be created in two ways:

First, sea-coast artillery formations should be organized in the national guard or militia, as now constituted in the several states, whenever the states will undertake to do this.

Second, a new sea-coast artillery force should be created.

3. In order to secure uniformity of organization and harmonious action, there should be one plan or system for the organization of our sea-coast artillery forces, and all the different units of the several forces should be given their proper places in the system.

4. All our sea-coast artillery forces should be given a reserve of their own, by adopting the system of short service with the colors, followed by a period in the reserve.

5. The territorial or localization system should be adopted for our sea-coast artillery forces; the country should be divided into artillery districts, and the force in each should be recruited chiefly from men located in the district.

6. All the sea-coast artillery forces should be organized and trained with a view to suddenly calling into the forts enough men, sufficiently trained, to make the guns most effective against a foreign foe.

Omitting the first specification under the second principle as being more a matter of temporary expediency, most artillery officers will probably give endorsement to the entire statement.

Differences of opinion are to be expected however with regard to the details of the second and fourth. It is in these details *and in the provision of a head for the entire artillery establishment* that the question of the efficiency of our artillery forces must and will find its solution.

Lieutenant Best gave good expression to this idea when he said,* referring to the report of the Artillery Council, "The great and crying need of the artillery was then and is now a direct head to arrange not only regarding the many important matters pertaining to a permanent artillery force but, equally important, to consider and plan for an efficient and prompt reinforcement of our sea-board defenses in the hour of need".

Whatever be the organization most desirable for efficiency in time of war, that adopted must be one that can be maintained under the constitution in time of peace. The state militia system is certainly within these limitations, but many doubt whether a national militia would be so. Colonel Sanger is evidently in favor of the former, and in his view will receive strong support, particularly from those occupying controling positions in state politics. To the army the possibility that the will of the government may be nullified by the failure of state authorities to enroll and train their proper complements of troops, is a condition most seriously to be feared.

In many other respects, apparent without further explanation, the state militia system of auxiliary troops would be the best.

The question is of such vital importance that it is worthy of the special consideration of Congress, even to the extent of authorizing the appointment of a special mixed commission of experts to investigate it and to outline anew a national policy, consistent with our institutions and sufficient for our military requirements.

As to the need of a *chief*, not to mention a corps organization, there is no question. Work is now waiting for his guiding hand and no one else is in position to do it. Boards of officers are from time to time being appointed to take up by piece-meal the more urgent matters which should be directed under his supervision. The results are good, and mark a long step of progress, but they are not complete, and do not bear that relation to each other that is desirable. The instruction of officers and troops at posts cannot be conducted according to a comprehensive plan for the greatest good to the service.

* "Wanted: a Fitting Artillery Organization", *Journal of the Military Service Institution*, November, 1895.

RANGE TABLES FOR THE 12-INCH CAST-IRON BREECH-LOADING MORTAR.

In the first number of the JOURNAL (January, 1892), were published range-tables for the 12-inch cast iron breeech-loading mortar for projectiles weighing 625 pounds, which was the weight of projectile first adopted. Since that time these light projectiles have been discarded for others weighing 800 pounds, and therefore the 1892 tables are obsolete.

In preparing the following tables all available data have been made use of especially in determining the proper charges for the various ranges and angles of departure. These undoubtedly will need more or less correction which can be made only by the results of actual target practice. The powder for which the calculations were made is *V M* brown prismatic for ranges of 2½ miles and upwards and *M IV* sphero-hexagonal for ranges less than 2½ miles.

It will be observed that the arrangement of the tables is entirely different from that universaly adopted in range tables for high-power guns. For these latter the muzzle velocity is assumed to be constant in computing the body of the table and the range becomes naturally the argument and occupies the first column of the table, followed immediately by a column of corresponding angles of departure. But from the peculiar nature of mortar firing such an arrangement would obviously be very inconvenient if not impracticable. After trying various forms for these tables that which is given here seemed to be the one best fitted for practical use.

The tables are computed, for the assumed ranges, for angles of departure extending from 30° to 65°; but in practice the limits of elevation will, with rare exceptions, be 45° and 60°. For angles of elevation less than 45° the vertical energy of descent is, except for extreme ranges, too small to accomplish the object desired; while for angles greater than 60° the projectile cannot be depended upon to keep point foremost in the descending branch, and therefore ceases to be a subject for calculation.

It is beleived that the "jump" has no practical existence in connection with the 12-inch mortar, while the drift and wind-effect are at present beyond our power of calculation. Their

effects, at the time of practice, must be determined by a trial shot.

For the manner of using the tables in action see the introduction to the original tables, already referred to at the beginning of this article.

These tables were computed by means of the "General Tables" published in No. 18 of the JOURNAL, and the columns "Muzzle velocity," "Time of flight," "Angle of fall" and "Striking velocity" are submitted with a good deal of confidence in their accuracy. The computations for the charges for the various ranges and angles of elevation were based upon the kinds of powder used in the practice firing of last year. Of course any change from these brands would render the charges here given more or less inaccurate. They may perhaps be of some assistance even upon this supposition.

As an illustration of how these (or similar) tables may be used in service, suppose we have cartridges carefully prepared weighing 80 lbs., 70 lbs., 60 lbs., etc. Of course the firing will begin at the longest practicable range which we will assume to be 5½ miles (9680 yards), and will require the heaviest cartridge. The first table shows that for the 80-pound cartridge the elevation should be 45°, which is the best elevation for this range. This same cartridge can also be used for a range of 5¼ miles (9240 yards), with angle of elevation 53° 37′; and 5 miles (8800 yards) and angle of elevation 57° 21′. For a range of 4¾ miles we may either employ a 70-pound cartridge at 46° or an 80-pound at 60° 27′, and so on. This suggests another arrangement of the tables in which the weights of the prepared cartridges and the ranges shall be the arguments.

Range-Tables for the 12-inch B. L. Mortar (cast-iron). Weight of projectile 300 lbs. Range 5½ miles (9680 yards).

Angle of elevation.	Muzzle velocity f. s.	Charge V M Brown Powder. Lbs.	Oz.	Variation of charge for variation of 100 yds. in range. oz.	Time of flight. seconds.	Angle of fall.		Striking velocity. f. s.
30°	1137	89	5	14	33.6	34°	23′	919
35	1092	83	12		37.0	39	36	897
40	1067	80	11		40.5	44	44	887
45	1061	80	0	12	44.3	49	43	892
46	1062	80	1		45.0	50	42	895
47	1064	80	5		45.8	51	41	898
48	1066	80	9		46.6	52	39	901
49	1069	80	15		47.4	53	37	905
50	1072	81	5	13	48.3	54	35	910
51	1076	81	12		49.2	55	33	915
52	1081	82	6		50.1	56	30	921
53	1086	83	0		51.0	57	27	927
54	1093	83	14		51.9	58	24	934
55	1100	84	11	13	52.9	59	20	941
56	1108	85	11		53.9	60	16	949
57	1117	86	13		54.9	61	12	957
58	1127	88	1		56.0	62	7	966
59	1137	89	5		57.1	63	2	976
60	1149	90	13	14	58.3	63	57	987
61	1162	92	8		59.5	64	51	998
62	1175	94	2		60.7	65	45	1010
63	1190	96	1		62.0	66	39	1023
64	1205	98	0		63.3	67	32	1036
65	1221	100	2	14	64.7	68	25	1050

Range 5¼ miles (9240 yards).

30	1107	85	9	14	32.8	34	12	902
35	1063	80	3		36.1	39	25	880
40	1039	77	4		39.5	44	33	869
45	1033	76	10	12	43.2	49	32	875
46	1034	76	12		43.9	50	31	877
47	1035	76	14		44.7	51	30	880
48	1037	77	1		45.5	52	29	883
49	1040	77	7		46.3	53	27	887
50	1043	77	13	13	47.1	54	25	891
51	1047	78	4		47.9	55	23	896
52	1052	78	14		48.8	56	20	901
53	1057	79	8		49.7	57	17	907

Range 5¼ miles (9240 yards).—concluded.

Angle of elevation.	Muzzle velocity. f. s.	Charge V M Brown Powder. Lbs.	Oz.	Variation of charge for variation of 100 yds. in range. oz.	Time of flight, seconds.	Angle of fall.	Striking velocity. f. s.
54	1064	80	5		50.6	58° 14′	914
55	1071	81	2	13	51.6	59 11	921
56	1079	82	2		52.6	60 07	929
57	1088	83	4		53.6	61 03	937
58	1097	84	6		54.6	61 59	946
59	1108	85	11		55.7	62 55	956
60	1119	87	1	14	56.8	63 50	966
61	1131	88	9		57.9	64 45	977
62	1145	90	5		59.1	65 40	988
63	1160	92	4		60.3	66 34	1000
64	1176	94	4		61.5	67 28	1013
65	1192	96	5	14	62.8	68 22	1027

Range 5 miles (8800 yards).

Angle of elevation.	Muzzle velocity. f. s.	Charge V M Brown Powder. Lbs.	Oz.	Variation of charge for variation of 100 yds. in range. oz.	Time of flight, seconds.	Angle of fall.	Striking velocity. f. s.
30	1076	81	12	14	32.0	34 01	884
35	1033	76	10		35.2	39 14	862
40	1010	73	14		38.5	44 21	851
45	1005	73	5	12	42.0	49 21	856
46	1006	73	7		42.7	50 20	858
47	1007	73	9		43.5	51 19	860
48	1009	73	13		44.3	52 18	863
49	1011	74	0		45.1	53 17	867
50	1014	74	6	13	45.9	54 15	871
51	1018	74	13		46.7	55 13	876
52	1023	75	7		47.6	56 11	881
53	1028	76	0		48.5	57 08	887
54	1034	76	12		49.4	58 05	893
55	1041	77	9	13	50.3	59 02	900
56	1049	78	8		51.2	59 58	907
57	1058	79	10		52.2	60 55	915
58	1067	80	11		53.2	61 51	923
59	1077	81	14		54.3	62 46	933
60	1088	83	4	14	55.4	63 42	944
61	1100	84	11		56.5	64 37	955
62	1113	86	5		57.7	65 32	967
63	1127	88	1		58.9	66 27	981
64	1143	90	1		60.2	67 22	997
65	1161	92	6	14	61.6	68 16	1013

Range 4¾ miles (8360 yards).

Angle of elevation.	Muzzle velocity. f. s.	Charge V M Brown Powder. Lbs.	Oz.	Variation of charge for variation of 100 yds. in range. oz.	Time of flight. seconds.	Angle of fall.		Striking velocity. f. s.
30°	1045	78	0	14	31.1	33°	50′	866
35	1003	73	2		34.3	39	03	844
40	981	70	8		37.5	44	10	833
45	976	69	14	12	40.9	49	10	836
46	977	70	0		41.6	50	09	838
47	978	70	2		42.4	51	08	840
48	980	70	7		43.1	52	07	843
49	982	70	10		43.9	53	06	847
50	985	71	0	12	44.7	54	04	851
51	989	71	7		45.5	55	02	855
52	993	71	15		46.3	56	00	860
53	998	72	8		47.1	56	58	866
54	1004	73	3		48.0	57	56	872
55	1011	74	0	13	48.9	58	53	879
56	1018	74	13		49.8	59	50	886
57	1026	75	12		50.8	60	47	894
58	1035	76	14		51.8	61	43	902
59	1045	78	0		52.8	62	39	912
60	1056	79	7	14	53.9	63	35	922
61	1067	80	11		55.0	64	31	932
62	1080	82	4		56.2	65	26	944
63	1094	84	0		57.4	66	21	957
64	1110	85	15		58.7	67	16	972
65	1128	88	3	15	60.0	68	10	988

Range 4½ miles (7920 yards).

30	1013	74	4	14	30.2	33	39	848
35	973	69	10		33.3	38	51	825
40	951	67	2		36.4	43	58	814
45	946	66	9	12	39.8	48	59	816
46	947	66	10		40.5	49	58	818
47	948	66	12		41.2	50	57	820
48	950	67	0		41.9	51	56	823
49	952	67	4		42.6	52	55	826
50	955	67	10	12	43.4	53	53	830
51	959	68	0		44.2	54	51	834
52	963	68	8		45.0	55	50	839
53	968	69	1		45.8	56	48	844

Range 4½ miles (7920 yards).—concluded.

Angle of elevation	Muzzle velocity. f. s.	Charge V M Brown Powder. Lbs.	Oz.	Variation of charge for variation of 100 yds. in range oz.	Time of flight. seconds.	Angle of fall.		Striking velocity. f. s.
54°	974	69	12		46.6	57°	46′	850
55	980	70	7	13	47.5	58	43	857
56	987	71	4		48.4	59	40	864
57	995	72	1		49.3	60	37	872
58	1003	73	2		50.3	61	34	881
59	1013	74	4		51.3	62	31	890
60	1024	75	9	14	52.4	63	27	900
61	1035	76	14		53.5	64	23	911
62	1048	78	6		54.6	65	19	922
63	1062	80	1		55.8	66	14	935
64	1077	81	14		57.0	67	9	948
65	1094	84	0	15	58.3	68	04	962

Range 4¼ miles (7480 yards).

30	981	70	8	14	29.3	33	28	829
35	942	66	2		32.3	38	39	805
40	921	63	12		35.3	43	46	793
45	916	63	3	12	38.6	48	48	795
46	917	63	5		39.2	49	47	797
47	918	63	7		39.9	50	46	799
48	920	63	10		40.6	51	45	802
49	922	63	14		41.3	52	44	805
50	925	64	3	12	42.1	53	43	809
51	928	64	9		42.8	54	42	813
52	932	65	0		43.6	55	40	818
53	937	65	9		44.4	56	38	823
54	943	66	4		45.2	57	36	829
55	949	66	14	13	46.1	58	34	835
56	956	67	12		47.0	59	32	842
57	963	68	8		47.9	60	29	849
58	972	69	8		48.9	61	26	857
59	981	70	8		49.9	62	23	866
60	992	71	12	14	50.9	63	19	876
61	1004	73	3		52.0	64	15	886
62	1017	74	11		53.1	65	11	897
63	1030	76	4		54.2	66	7	909
64	1045	78	0		55.4	67	2	922
65	1060	79	13	15	56.6	67	57	936

Range 4 miles (7040 yards).

Angle of elevation.	Muzzle velocity. f. s.	Charge V M Brown Powder. Lbs.	Oz.	Variation of charge for variation of 100 yds. in range. oz.	Time of flight. seconds.	Angle of fall.		Striking velocity. f. s.
30°	948	66	12	14	28.4	33°	16′	808
35	910	62	9		31.3	38	27	785
40	890	60	6		34.2	43	34	772
45	885	59	13	12	37.4	48	36	774
46	886	59	15		38.0	49	36	776
47	887	60	1		38.7	50	35	778
48	889	60	4		39.4	51	34	780
49	891	60	7		40.1	52	33	783
50	894	60	13	12	40.8	53	32	787
51	897	61	2		41.5	54	31	791
52	901	61	9		42.3	55	30	795
53	906	62	2		43.1	56	28	800
54	911	62	11		43.9	57	26	806
55	917	63	5	13	44.7	58	24	812
56	923	64	0		45.5	59	22	818
57	930	64	13		46.4	60	19	825
58	939	65	13		47.4	61	16	833
59	948	66	12		48.3	62	13	842
60	958	67	15	14	49.3	63	10	851
61	968	69	1		50.3	64	06	860
62	980	70	7		51.4	65	03	871
63	993	71	14		52.5	65	59	883
64	1008	73	11		53.6	66	54	895
65	1024	75	9	15	54.8	67	50	909

Range 3¾ miles (6600 yards).

Angle of elevation.	Muzzle velocity. f. s.	Charge Lbs.	Oz.	Variation of charge	Time of flight.	Angle of fall.		Striking velocity.
30	914	63	0	14	27.4	33	04	786
35	878	59	0		30.2	38	16	763
40	858	56	15		33.1	43	22	751
45	853	56	7	12	36.1	48	24	752
46	854	56	8		36.7	49	24	753
47	855	56	10		37.4	50	23	755
48	857	56	13		38.0	51	23	757
49	859	57	0		38.7	52	22	760
50	862	57	6	12	39.4	53	21	763
51	865	57	11		40.1	54	20	767
52	869	58	2		40.8	55	19	772
53	873	58	8		41.6	56	18	777

Range 3¾ miles (6600 yards).—concluded.

Angle of elevation.	Muzzle velocity f. s.	Charge V M Brown Powder.		Variation of charge for variation of 100 yds. in range. oz.	Time of flight. seconds.	Angle of fall.		Striking velocity. f. s.
		Lbs.	Oz.					
54°	878	59	0		42.4	57°	16′	782
55	884	59	12	13	43.2	58	14	788
56	890	60	6		44.0	59	12	794
57	897	61	2		44.9	60	09	800
58	905	62	0		45.8	61	07	808
59	914	63	0		46.7	62	04	816
60	924	64	2	14	47.7	63	01	825
61	934	65	3		48.7	63	58	835
62	946	66	9		49.7	64	55	845
63	959	68	0		50.8	65	51	857
64	973	69	10		51.9	66	47	869
65	988	71	5	15	53.0	67	43	882

Range 3½ miles (6160 yards).

30	879	59	3	14	26.4	32	53	763
35	844	55	7		29.1	38	04	740
40	826	53	9		31.9	43	10	729
45	821	53	1	12	34.8	48	12	729
46	822	53	2		35.4	49	12	730
47	823	53	4		36.0	50	12	731
48	824	53	6		36.7	51	11	733
49	826	53	9		37.3	52	11	736
50	829	53	14	13	38.0	53	10	739
51	832	54	3		38.7	54	09	743
52	836	54	10		39.4	55	08	747
53	840	55	0		40.1	56	07	752
54	845	55	9		40.9	57	06	757
55	851	56	3	13	41.7	58	04	763
56	857	56	13		42.5	59	02	769
57	864	57	9		43.3	59	59	775
58	872	58	7		44.2	60	57	782
59	881	59	6		45.1	61	54	790
60	890	60	6	14	46.0	62	51	799
61	900	61	7		47.0	63	48	809
62	911	62	11		48.0	64	45	819
63	923	64	0		49.0	65	42	830
64	936	65	8		50.1	66	39	842
65	950	67	1	15	51.2	67	35	854

Range $3\frac{1}{4}$ miles (5720 yards).

Angle of elevation.	Muzzle velocity. f. s.	Charge V M Brown Powder. Lbs.	Oz.	Variation of charge for variation of 100 yds. in range. oz.	Time of flight. seconds.	Angle of fall.	Striking velocity. f. s.
30°	844	55	7	14	25.4	32° 42′	740
35	810	52	0		28.0	37 52	716
40	793	50	3		30.7	42 58	705
45	788	49	11	12	33.5	47 59	705
46	788	49	11		34.1	48 59	706
47	789	49	12		34.7	49 59	707
48	790	49	14		35.3	50 59	709
49	792	50	1		35.9	51 58	711
50	795	50	6	13	36.6	52 58	714
51	798	50	11		37.2	53 58	718
52	801	51	0		37.9	54 57	722
53	805	51	6		38.6	55 56	727
54	810	52	0		39.3	56 55	732
55	816	52	9	13	40.1	57 53	738
56	822	53	2		40.8	58 51	743
57	829	53	14		41.6	59 48	749
58	836	54	10		42.4	60 46	755
59	845	55	9		43.3	61 44	763
60	854	56	8	14	44.2	62 41	771
61	864	57	9		45.1	63 39	779
62	874	58	10		46.0	64 36	787
63	886	59	15		47.0	65 33	797
64	899	61	6		48.1	66 30	810
65	912	62	12	16	49.2	67 27	824
Range 3 miles (5280 yards).							
30	808	51	11	14	24.4	32 30	716
35	776	48	8		26.9	37 39	691
40	759	46	13		29.4	42 45	680
45	754	46	5	12	32.1	47 46	679
46	754	46	5		32.7	48 46	680
47	755	46	6		33.3	49 46	682
48	757	46	9		33.9	50 46	684
49	759	46	13		34.5	51 46	686
50	761	46	15	12	35.1	52 46	689
51	764	47	3		35.7	53 46	693
52	767	47	9		36.3	54 45	697
53	771	48	0		37.0	55 44	701

Range 3 miles (5280 yards).—concluded.

Angle of elevation.	Muzzle velocity. f. s.	Charge V M Brown Powder. Lbs.	Oz.	Variation of charge for variation of 100 yds. in range. oz.	Time of flight. seconds.	Angle of fall.	Striking velocity f.s.
54°	776	48	8		37.7	56° 43′	706
55	781	49	0	13	38.4	57 42	711
56	786	49	8		39.1	58 40	716
57	792	50	1		39.9	59 38	722
58	799	50	13		40.7	60 36	728
59	807	51	10		41.5	61 33	734
60	816	52	9	14	42.4	62 31	741
61	825	53	7		43.3	63 29	749
62	835	54	8		44.2	64 26	759
63	846	56	9		45.2	65 24	769
64	859	58	0		46.2	66 22	781
65	872	58	7	16	47.2	67 19	793

Range 2¾ miles (4840 yards).

30	770	47	14	14	23.3	32 18	689
35	740	44	15		25.7	37 26	666
40	724	43	6		28.1	42 33	653
45	718	42	13	13	30.7	47 34	652
46	718	42	13		31.2	48 34	653
47	719	42	14		31.8	49 34	655
48	721	43	1		32.3	50 34	657
49	723	43	5		32.9	51 34	659
50	725	43	8	13	33.5	52 34	662
51	728	43	12		34.1	53 34	666
52	731	44	1		34.7	54 34	670
53	735	44	7		35.3	55 33	674
54	740	44	15		36.0	56 32	678
55	745	45	6	13	36.7	57 31	683
56	750	45	14		37.4	58 29	687
57	756	46	7		38.1	59 26	692
58	762	47	1		38.9	60 24	697
59	770	47	14		39.7	61 22	704
60	778	48	11	14	40.5	62 20	711
61	787	49	9		41.3	63 18	719
62	796	50	8		42.2	64 16	727
63	807	51	10		43.1	65 14	737
64	818	52	12		44.1	66 12	749
65	831	54	1	16	45.1	67 10	761

Range 2½ miles (4400) yards.

Angle of elevation.	Muzzle velocity. f. s.	Charge V M Brown Powder. Lbs.	Oz.	Variation of charge for variation of 100 yds. in range. oz.	Time of flight. seconds.	Angle of fall.		Striking velocity. f. s.
30°	731	44	1	14	22.2	32°	06′	660
35	702	41	5		24.5	37	12	638
40	687	39	14		26.7	42	20	626
45	682	39	7	12	29.2	47	22	624
46	682	39	7		29.7	48	22	625
47	683	39	8		30.2	49	22	626
48	684	39	10		30.8	50	22	628
49	686	39	13		31.3	51	21	630
50	688	40	0	13	31.9	52	21	633
51	691	40	4		32.5	53	21	636
52	694	40	9		33.0	54	21	640
53	698	40	15		33.6	55	21	644
54	702	41	5		34.2	56	20	648
55	707	41	12	13	34.9	57	19	652
56	712	42	4		35.5	58	17	656
57	717	42	11		36.2	59	15	660
58	723	43	5		37.0	60	14	666
59	730	43	15		37.7	61	12	672
60	738	44	12	14	38.5	62	10	679
61	747	45	10		39.3	63	08	687
62	756	46	7		40.2	64	06	696
63	766	47	8		41.1	65	05	705
64	777	48	9		42.0	66	03	716
65	789	49	12	16	43.0	67	01	727

Range 2¼ miles (3960 yards).

M W Sph.-Hex.

Angle of elevation.	Muzzle velocity. f. s.	Lbs.	Oz.	Variation of charge for variation of 100 yds. in range. oz.	Time of flight. seconds.	Angle of fall.		Striking velocity. f. s.
30	691	37	4	13	21.0	31	55	630
35	663	34	13		23.2	36	58	609
40	648	33	10		25.3	42	07	597
45	644	33	4	12	27.6	47	10	595
46	644	33	4		28.1	48	10	596
47	645	33	5		28.6	49	10	597
48	646	33	7		29.1	50	10	598
49	648	33	10		29.6	51	09	600
50	650	33	12	12	30.2	52	09	602
51	652	33	14		30.7	53	09	605
52	655	34	3		31.3	54	08	608
53	659	34	8		31.9	55	08	611

Range 2¼ miles (3960 yards).—concluded.

Angle of elevation.	Muzzle velocity. f. s.	Charge M W Sphero.-Hex. Lbs.	Oz.	Variation of charge for variation of 100 yds. in range. oz.	Time of flight. seconds.	Angle of fall.	Striking velocity. f. s.
54	663	34	13		32.5	56° 07′	615
55	667	35	3	12	33.1	57 06	619
56	672	35	10		33.7	58 05	623
57	677	36	0		34.3	59 03	628
58	683	36	8		35.0	60 02	633
59	690	37	2		35.7	61 00	639
60	697	37	12	13	36.5	61 59	646
61	705	38	7		37.2	62 58	653
62	714	39	4		38.0	63 56	661
63	723	40	0		38.9	64 54	670
64	733	40	14		39.8	65 53	680
65	745	42	0	14	40.7	66 51	691

Range 2 miles (3520 yards).

Angle of elevation.	Muzzle velocity. f. s.	Charge M W Sphero.-Hex. Lbs.	Oz.	Variation of charge for variation of 100 yds. in range. oz.	Time of flight. seconds.	Angle of fall.	Striking velocity. f. s.
30	649	33	11	13	19.8	31 43	600
35	623	31	8		21.8	36 44	577
40	608	30	5		23.8	41 54	565
45	605	30	1	12	26.0	46 57	563
46	605	30	1		26.4	47 57	564
47	606	30	2		26.9	48 57	565
48	607	30	4		27.4	49 57	566
49	608	30	5		27.9	50 56	568
50	610	30	7	12	28.4	51 56	570
51	612	30	10		28.9	52 56	572
52	615	30	14		29.5	53 55	575
53	618	31	1		30.0	54 54	578
54	622	31	7		30.6	55 54	581
55	626	31	12	12	31.2	56 53	585
56	630	32	1		31.8	57 52	589
57	635	32	8		32.4	58 51	594
58	641	33	0		33.0	59 50	600
59	647	33	8		33.7	60 49	606
60	654	34	2	13	34.4	61 48	612
61	661	34	11		35.1	62 47	619
62	669	35	6		35.8	63 45	627
63	678	36	2		36.6	64 44	635
64	687	36	14		37.4	65 43	644
65	698	37	13	14	38.2	66 41	653

Range 1¾ miles (3080 yards).

Angle of elevation.	Muzzle velocity. f. s.	Charge MW Sph. Hex. Lbs.	Oz.	Variation of charge for variation of 100 yds. in range. oz.	Time of flight. seconds.	Angle of fall.		Striking velocity. f. s.
30°	604	30	1	13	18.4	31°	30′	566
35	581	28	3		20.3	36	30	542
40	566	27	1		22.3	41	41	531
45	564	26	14	12	24.3	46	44	528
46	564	26	14		24.7	47	44	529
47	564	26	14		25.1	48	43	530
48	565	26	15		25.6	49	43	531
49	566	27	1		26.0	50	42	533
50	568	27	3	12	26.5	51	42	535
51	570	27	5		27.0	52	42	537
52	573	27	9		27.5	53	41	540
53	576	27	13		28.0	54	41	543
54	579	28	0		28.5	55	40	546
55	583	28	5	12	29.1	56	40	550
56	587	28	10		29.7	57	39	554
57	592	29	1		30.2	58	39	558
58	597	29	8		30.8	59	38	563
59	603	29	15		31.4	60	38	569
60	609	30	7	13	32.1	61	37	575
61	616	30	15		32.8	62	36	581
62	623	31	8		33.5	63	35	588
63	631	32	3		34.2	64	33	596
64	640	32	14		34.9	65	32	604
65	649	33	11	14	35.7	66	30	613

Range 1½ miles (2640 yards).

Angle of elevation.	Muzzle velocity. f. s.	Charge MW Sph. Hex. Lbs.	Oz.	Variation of charge for variation of 100 yds. in range. oz.	Time of flight. seconds.	Angle of fall.		Striking velocity. f. s.
30	557	26	6	13	17.0	31	18	526
35	535	24	12		18.8	36	17	506
40	522	23	12		20.6	41	28	495
45	520	23	10	12	22.5	46	30	492
46	520	23	10		22.9	47	30	492
47	520	23	10		23.3	48	29	492
48	521	23	11		23.7	49	29	493
49	522	23	12		24.1	50	28	494
50	524	23	14	12	24.5	51	28	496
51	526	24	0		24.9	52	28	498
52	528	24	3		25.4	53	28	500
53	531	24	7		25.9	54	27	503

Range 1½ miles (2640 yards).—continued.

Angle of elevation.	Muzzle velocity. f. s.	Charge M W Sphero.-Hex.		Variation of charge for variation of 100 yds. in range. oz.	Time of flight. seconds.	Angle of fall.	Striking velocity. f. s.
		Lbs.	Oz.				
54	534	24	10		26.4	55° 27′	506
55	537	24	14	12	26.9	56 27	510
56	541	25	3		27.4	57 27	514
57	545	25	7		28.0	58 26	518
58	550	25	13		28.5	59 26	523
59	555	26	3		29.1	60 25	528
60	561	26	10	13	29.7	61 25	534
61	567	27	1		30.3	62 24	540
62	574	27	10		30.9	63 22	547
63	581	28	3		31.6	64 21	554
64	589	28	13		32.3	65 20	561
65	598	29	9	14	33.0	65 19	569

Captain James M. Ingalls, First Artillery,
Instructor U. S. Artillery School.

PROFESSIONAL NOTES.

ORGANIZATION.

The Army in 1896—Argentine Republic.

According to the budget fixed for the year 1896 the permanent army will comprise:

One regiment of engineers, 3 brigades of field artillery, 1 brigade of mountain artillery, 16 regiments (of 1 battalion each) of infantry, and 11 regiments of cavalry, (each of 3 squadrons).

The regiment of engineers preserves its old organization and its companies of sappers, pontonniers, telegraphers and railroad workmen until the arrival of the new material with which it is to be provided; this material has just been purchased in Europe.

Each of the 4 brigades of field and mountain artillery is composed of 2 regiments, of three batteries each, with 6 pieces to a battery; a regiment is commanded by a lieutenant-colonel, a brigade by a colonel, and the combined brigades form a division under the orders of a general.

In 1895 there were 12 regiments of infantry,—or rather 12 battalions as nuclei for 12 regiments,—4 new ones have been formed, which will be, like the old ones, commanded by colonels. An 11th regiment of cavalry is also being organized, so that this arm is increased by one regiment.

A commission, presided over by Colonel Obligado, is at present in the works of Krupp at Essen, to superintend the construction of 180 field guns ordered from this establishment. The artillery will receive a part of this new armament during the month of January, 1896; ultimately it will be able to form 30 batteries of six pieces each. Another commission, presided over by Lieutenant-Colonel Day, has gone to the United States to receive the revolvers intended for the cannoneers of the ordinary field batteries and the horse artillery batteries, in place of the carbines with which they are now provided; the cannoneers will also receive short sabres and machetes (cutlasses) in place of the long sabres of the model at present in service.

The men engage to serve for two years, with a bounty of $200, one-half of which to be paid on signing the contract, the other at the end ot the engagement.

—*Revue du Cercle Militaire*, January 25, 1896.

TACTICS.

Thoughts on the Employment of Cavalry and Mounted Artillery in Battle.

The fact that the eyes of military readers are once more directed in a high degree towards horse artillery furnishes cause for reasonable rejoicing. For the good of the army it is to be hoped that it will bring about a proper appreciation of this arm of the service, or rather enable it to reclaim its former prestige.

Formed at a time when field artillery, as a general thing, partook of the character of position artillery, horse artillery for a long time was the only representative of mobile artillery. At a time of verv meagre state appropriations, it alone received sufficient allowances to enable it to keep well drilled

and in a mobile condition; on account of this it became the ideal and representative of the entire field artillery. Having been brought up in a certain exclusive spirit, and endeavoring to excel in those directions only, it attracted all eyes to itself. To this must be added the great influence lent by the smooth bore guns firing canister, which produced an effect two or threefold better than that of the small arm—an effect which enabled horse artillery to assume that splendid rôle which it has played in attacks.

How different to-day!

In regard to mobility, field artillery has successfully emulated horse artillery. The rapidly increased effect of all firearms prevents the latter from getting at close range in the open, and forces it, just as it does field artillery, to seek cover, perhaps even to a greater degree, on account of the larger target it furnishes. Moreover, many authorities claim that the value of cavalry on the field of battle has greatly diminished, with the advent of modern fire arms, and this has brought about a corresponding reduction in value of its auxiliary arm. It is not surprising then that the necessity of its existance is often questioned, and still oftener the feeling is created that it is not worth its cost.

Too often it is experienced that cavalry is hampered in its movements by horse artillery and this causes the former to feel glad to get rid of the encumbrance whenever it can do so, and the commanding officer of the troops finds it embarrassing when he attempts to prescribe movements for the heavier arm strictly conformable to its nature.

And yet, what important duties await it in time of need! Duties, which, if understood and properly carried out, will give to small divisions of this arm an importance which far outranks that given to similar divisions of other arms of the service (such duties have been referred to in No. 4, of the *Militär-Wochenblatt*. But the reason for most of them is not given).

Generally horse artillery is expected to prepare the fight for the cavalry action. On account of this it is a disputed question whether this artillery should belong to the corps artillery or not; which fact in itself shows that the value of the artillery is not overrated.

To make clear the above statements it is necessary to imagine a picture of the course a modern battle would assume. If we form a conception of the enormous increase in the effect produced by all arms it will appear that the defensive has gained very much in strength. It is difficult to conceive, how, in the hail of projectiles which will sweep over a modern battlefield, it is possible to bring up troops against the opponent. And yet this will have to be done and it will be done; it would be a fatal error not to believe that the offensive has the advantage now as it always has had.

The possibility of effectively bringing about this advantage still lies in a daring and able use of the artillery. Much time is wasted quarreling about whether the infantry attack shall be a normal one or not; but this quarrel is to no purpose. If the artillery does not do the main work, no infantry in the world will be able to make, in any formation whatsoever, a successful attack on a position strongly occupied and well defended. On the other hand, only such a defense as controls not only a reserve of cavalry and infantry, but also one of artillery, will be able to resist an offensive movement which is strongly supported by plenty of artillery. In order to bring about, under all circumstances, a daring and decisive artillery action, horse artillery is necessary. The following considerations will make this clear.

Examining the factors on which the probabilities of a victory depend, one

of the most important will be found to be the ability to throw one's superiority on the enemy's weak points. The greater the skill of the commander and the greater the maneuvring ability of the troops, the greater will be the possibility that inferior numbers may fight successfully against superior forces. Herein is found the main secret of the successes of both Frederick the Great and of Napoleon.

The weakest parts of a line of battle, be it remembered, are the flanks unless the terrain offers peculiar advantages. Hence the constant endeavor of the assailant to make flanking or turning movements. But the case also has its reverse side. He who outflanks the enemy may be himself outflanked, and the greater and more daring the outflanking has been carried out, the greater will be the lengthening out and the consequent danger of being pierced through. Nevertheless this mode of attack will take place, and it must be borne in mind, that the enemy's danger increases with the boldness with which our lines carry it out; but, as already stated, our own dangers grow greater, and later become so pressing that only one arm of the service can expose itself to it—one which combines in itself a certain powerful initiative with celerity of movement, thus making it to a certain degree invulnerable—and this arm is horse artillery in combination with cavalry.

Every battery which is not in actual action will be severely missed; this fact must be duly appreciated; one can never be too strong to silence the enemy's artillery. But what is lost in the front, is gained two and threefold on the flanks. The objection may be raised that the enemy's front will again be encountered even on the flanks, especially if it gets to be a matter of general custom to make such flank attacks by means of horse artillery and cavalry; this is the more certain as any movement, even when made under cover, is apt to be discovered in time on account of the dust that will be raised. This is quite true. Nevertheless, he who has been obliged to have one of his wings fall back, will still be outflanked; *i. e.* both his front and his new defensive flank will be taken in flank, the former by the flanking artillery and the latter by the artillery in front. And in regard to the importance of a flank attack it must be remembered that nowadays an artillery fight will chiefly be conducted from positions which cannot be observed by the opposite foe, but which can neither be hidden nor screened from a flanking foe.

This is another reason for a commander to strive to have horse artillery; let it be closely united with cavalry, and give it orders to boldly and confidently attack the enemy's most vital position whenever possible; let him count on its powerful effect and let him rely on its ability to meet threatening dangers with its own fire and that of its cavalry support, and let him rest assured that it can get out of the way of superior danger by its own mobility and celerity.

The question is often discussed as to the value of cavalry as a fighting arm on the line of battle. Aside from the fact that it is not at all our intention to deny its value, we believe that cavalry will make a proper return and pay for itself in battle, even if it does nothing else than assist in bringing a powerful artillery effect on the enemy's flanks and rear.

In many respects the rôles of these two arms have changed places; cavalry, in regard to its duty in battle, might almost be called the auxiliary arm of horse artillery. Whereas formerly the rôle of such artillery as was combined with fighting cavalry was to prepare the way for the attack of the latter, modern tactical conditions require that the main effort of cavalry during a battle be so made, as to enable a part of the artillery, the horse artillery, to

make such daring operations as will be the key to brilliant successes in spite of the great danger that may be incurred. In further considering the rôles of these combined arms, it will be clear that not only will they in all probability prepare the way to victory against the attacked flank, but will possibly carry the victory to annihilation. For woe to the retreating foe who has a strong hostile force of daring cavalry and horse artillery on his flank or perhaps even in his rear.

Again the objection may be entered that these remarks may well apply to small battles, but that in considering larger conditions it will be found that the space on which such tactical maneuvers may take place will be much too small in comparison with the whole line of battle, as to enable them to exert a deciding influence on the progress of the whole line of battle. Yet, in looking over war history, it will be found that the appearance of these two arms, in the above sense, was of a deciding influence in a great number of the largest battles.

But great success awaits these arms not only on the flank and in the rear, but also along the front. Even if the battle should be waged along the front by simply attempting to hold the ground, cases may nevertheless arise in which the decision will be sought there. But when that happens it will be of the greatest importance to concentrate a preponderating strength of artillery on the deciding position. Infantry will only be in a position to advance when it has in rear of the space on which it is to fight and over which it is to advance, a superior artillery. Only when this latter is able to keep back under their cover the enemy's infantry and artillery will it be possible for the infantry to advance from their protecting heights and approach the enemy's position. The fate of the attack will be decided at the moment our artillery succeeds in getting a firm foothold on the heights, such as will enable it to cover with its fire the space to be crossed by the infantry. Therefore everything will depend on massing the artillery effect at the place where the infantry must advance to the attack, and increasing it to such a degree that that of the enemy will be kept down; but to do this, fresh artillery will be necessary, not only to fire side by side with the artillery already in action, but to take position, if necessary, in front of the line already established. Now, after the last wars, it is a fundamental law to develop from the start the entire artillery. This law may be a far going reaction brought about by the wrong use that was made of the corps artillery in the war of 1866—a use carried out in the sense of the characteristic name it then had, namely,—reserve artillery. But it is at least questionable whether it will not be found necessary in future campaigns to have a protected reserve to make good the greater losses artillery will henceforth suffer. It is believed that such a reserve will be necessary, not only to replace artillery that may have been silenced, but also to permit of a massing of artillery on a deciding position to a degree not heretofore witnessed. The accuracy of the fire and the control over it, enables artillery to unhesitatingly out-shoot all other arms. Since this enables it to fire from such a range as to put it out of all danger or at any rate into so little danger, that its own losses in war will not weigh in the balance, advantage should be taken of this fact; and he who first and best understands this will have gained one of the most important factors of victory.

These considerations answer an oft repeated question as to whether we already have too much artillery. The remark is often heard that battlefields do not offer sufficient room and that infantry would only be a supporting arm.

This opinion can be correct only in the event of clinging to formations, heretofore in vogue, of fighting together side by side. instead of deciding once for all to make extended use of the heretofore condemned custom of firing over our own troops. On the other hand, unlimited demands for the increase of artillery should not be made; it is impossible to give to every corps such a strong force of artillery that it can have this double reserve at its disposition. Nor is this necessary. The decision of the battle will not be sought along every point of the front, and for ordinary purposes a first reserve, which will be able to take the place of silenced artillery and to withstand the attack of the enemy, will suffice. The second reserve, the one that must seek to gain a decisive action, must be common to several corps. But as it is impossible to know the place when such a decision will be sought, before, or even at the beginning of a battle, it will be practicable to mass the artillery at the required point only during the progress of the battle and therefore a high degree of mobility and celerity will be required of it.

It will be seen that horse artillery will be preferably employed for this purpose. Then, too, the observation, that horse artillery, on account of the larger target it affords, is less properly employed in a pitched battle, points to the fact that whenever artillery is to be held in reserve, horse artillery is to be preferred for this purpose, little as it may please its officers.

Let us still further consider the rôle of this artillery mass. It has been observed that one of the duties of artillery is to break through its own artillery line and take up a position in advance. Whether this position is to be taken immediately in front of the latter or at a greater distance in advance, whether it shall do so before or after the infantry line has passed that of the artillery, all this will depend on the terrain and the conditions of the battle.

It will certainly often be necessary, after leaving its cover, to pass over comparatively long distances through the enemy's fire, a circumstance which again calls for the use of horse artillery, as it will the soonest develop a celerity in which alone it can find protection against the enemy's fire. If these three artillery groups together have made it possible for the infantry to approach within a short distance of the enemy's fire so as to make a successful assault feasible, another moment will have come which calls for the most rapid handling of the artillery, namely, the occupation of the captured position. At this stage, minutes are so valuable, that only the utmost celerity will insure a decided success. Just consider the state of affairs. What troops will there be that will not storm against the infantry that succeeded in taking the position! Reserves will advance from every direction and the fire of all the batteries within range will be concentrated on it. If the advantage, so bloodily obtained, is not to be lost. immediately, the quickest possible bringing up of the artillery will be necessary, and this again calls for horse artillery, properly protected by its cavalry support. If this is done with celerity and energy, it will not only be possible to hold the advantage thus gained, but to push the action on to victory.

The significance of the timely bringing up of these masses of horse artillery with the cavalry supports, to make an energetic pursuit in order to derive the the full results of victory, has already been pointed out; we simply wish to call attention, in conclusion, to the picture which would be presented had it been possible to hold in readiness such masses on one or even both flanks at the same time.

According to our idea, this is the rôle horse artillery should play in an attack. It ought to be the last, deciding trump which the Commanding General

will play in order to prepare for his infantry the way to victory, and to gather in the fruits of the same with his cavalry. But it is not only in the attack in which it plays such an important rôle.

Sometimes the most important work will fall to its lot in the defense: for if we think of an attack as above described,—where an extensive development of artillery is made use of against our position,—it will be easy to appreciate the meaning of several cavalry divisions with a strong force of horse artillery behind our line of battle.

If we pass from the somewhat ideal ground on which the rôles of cavalry and horse artillery have been depicted, to the real ground, and attempt to put these ideas into execution at our maneuvers, we will at once encounter the fact elsewhere complained of, that the relations, which in war are the rule, existing in a great pitched battle, in which, in particular, we pictured the action of horse artillery as taking place, in time of peace for various reasons are but little, if at all, brought into play. At our maneuvers our numbers are usually comparatively very small in relation to the ground covered, and many of the above suggestions will be impracticable. The extension of the troops, on account of the small number, is generally so great that it is impossible to to think of massing the artillery in the sense indicated above.

However, daring flanking movements can be made of more worth under small proportions than under larger ones.

The higher commanding officers may therefore eliminate the fear that they may lose their artillery when they turn it over to their cavalry, and instead be confident that in so doing, the artillery may be of threefold use. At the same time, the cavalry leaders, when intrusted with such a powerful weapon, must be cognizant of the duties they assume with it and of the meaning the correct use of it may have for the whole battle and not merely for the cavalry alone.

They must not be jealous when at the commencement of the fight their battle duties will keep their arm in the background while horse artillery is brought to the foreground. The more, on the contrary, they bring themselves to acknowledge the fact during this time, that the artillery effect is of as much advantage to them as it is decisive on the whole line of battle, the brighter will be the prospect of a brilliant action for their arm of the service after the artillery has done its duty.

But grave duties also fall to the lot of the artillery. It must try to free the cavalry from the fear that with artillery has been acquired a ballast which is difficult to protect and difficult to move; it must endeavor to obtain a good footing with cavalry by showing it that in regard to mobility it can hold its own with any cavalry. To do this, artillery must constantly strive to do its utmost in the development of celerity of action and endurance on the field, and must constantly bear in mind that the moments of defenselessness, which are those of limbering and unlimbering, must be reduced to a minimum. Great attention should be paid to the limbers; driving them up to the guns at a gallop, hitching up the ammunition wagons rapidly, or preferably not having them unhitched in the first place but simply unlimbered, will aid to diminish the too often painfully long period of limbering up.

In its movements it must always have its eyes and ears open; it must not be too anxious to constantly have the cavalry in view and occasionally must not be afraid to go at a greater distance away from it; but in such a case it must not neglect to surround itself with a complete network of mounted scouts in order to receive timely information of any threatened danger, which it must meet by quick action either with its own fire or by getting out of the

way as soon as possible. The artillery commander will thus assume grave responsibilities, but he must not shirk doing so. He must be daring, determined and cautious. If he is this, and if he, as well as the general-in-chief and the cavalry commander, understand the duties of horse artillery in the spirit represented above, then not only horse artillery, but also cavalry, will again acquire an importance in battle which will amply satisfy the *esprit de corps* of the same, and, what is of the first consideration, will be of the utmost value for the welfare of the army.

The deductions that follow if we admit the correctness of these opinions, will be left to a future examination.

—*Militär-Wochenblatt*, No. 89, October 9, 1895.

[*Translated by* First Lieutenant H. C. SCHUMM, Second Artillery.]

DRILL REGULATIONS AND MANEUVERS.

The Grand Maneuvers in France in 1896.

In regard to the grand maneuvers to be held this year, propositions have been made, the acceptance of which will probably be decided upon in the near future. General Boisdeffre, Chief of the General Staff of the Army is said to have made these propositons to the war minister and with the approval of the higher war council.

The maneuvers will be on a large scale and will involve as a principal feature a practical attempt to bring three complete army corps on the field of maneuver, viz: The 5th (Orléans), 9th (Tours) and the 11th (Nantes). It is proposed to transport these 3 corps by train to Champagne there to oppose the advance of the 6th corps, which will have set out from the camp at Chalons representing the enemy. Moreover, fortification maneuvers on a large scale are contemplated for the troops of the intrenched camp of Paris, to which the division stationed in Rouen is to be called. General Saussier, the governor of Paris, is said to contemplate giving these fortification maneuvers an extensive development.

It is, however, doubtful whether these exercises will be carried out on the extensive scale proposed, mainly on account of the great expense involved.

—*Allgemeine Militär Zeitung*, January 16, 1896.

ARTILLERY MATERIAL.

a. Guns and Carriages.

Curved Fire or Torpedo Shell?

[Under this title Major F. Mariani of the Italian artillery has lately published in the *Revista Militare Italiana* (of August 1, 1895) an interesting plea in favor of the adoption of a piece with curved fire for the field artillery.

We give herewith a résumé of the main points in this article.—ED].

Notwithstanding the intrinsic value of projectiles as such, there are particular circumstances in which their effect diminishes so as to be almost reduced to zero. This is the case when the troops fired upon take shelter behind intrenchments in order to avoid the hail-storm which, without that precaution, would be almost unendurable.

It was in this way, for example, that, according to the report of General Todleben, a Russian battery under Plevna fired for a whole day against an intrenched position and only disabled one Turk.

This insignificant result is traceable to the flatness of the trajectories of field

guns. As a matter of fact, in order to reach a man seated with his back against the interior slope of the parapet the angle of fall must be at least 21° in case of shelter trenches, and 27° to 45° in case of regular intrenchments.

Now, since the angle of fall does not have as high a value as 20° in field guns until the range exceeds 4000 m. (4333 yards) it is evident that these pieces are powerless in the face of objects so disposed. In practice it is not even worth while to take account of the increase in inclination in case of shrapnel due to the spreading of the sheaf, for it is not until the range exceeds 2700 m. (2925 yards) that this over inclination begins to produce any really appreciable effect under the circumstances here considered. We can say then—without yielding to the temptation to merely play upon words—that the extraordinary power acquired by field guns has led them in certain cases to impotence.

This impotency is evidently only contingent; but the contingency will be frequent, for tactics will not fail to employ field fortifications very largely.

The first to attempt to find a remedy for this state of affairs were the Russians. Without troubling themselves too much with the question of complication of material they have quietly introduced mortars into their field artillery. By thus supplying the qualities which the pieces of direct fire lack, they are henceforth in condition to get even with all defilade. This is an expeditious solution, well in accord with the system employed in a country where the military expenses are completely under the control of the sovereign.

The other countries have shown themselves little disposed to follow the example of Russia.

Since the time of Gustavus Adolphus the constant aim of the artillerists has been to give to the field artillery all the uniformity and all the simplicity compatible with its rôle, and so they have always dreamed of realizing at the same time uniformity of caliber and of projectile.

For the campaign of the Crimea Napoleon III had obtained unity of caliber with the howitzer of 12 cm. (4.7 inch), but we were then very far from having unity of projectile. The advent of rifling, carrying with it the general adoption of oblong projectiles, brought artillerists at last to the eve of realizing that last part of their dream. And now comes Russia with her mortar to upset all their plans.

Either to disregard the facts which compelled that power to return to the old errors, or to give up the ideal looked forward to for so long a time and just about to be realized,—this was the dilemma in which the new situation placed them.

It was quite natural that the artillerists should seek to effect a compromise, to make terms with the difficulties of the question, inasmuch as an imitation of Russia would affect not only the caliber and projectile, but also the type of gun and the kind of fire.

The idea then was to see whether, while keeping in service the gun properly so called, and consequently direct fire alone, the advantages which the cover of field fortifications affords to the enemy can be overcome. It appeared that we had found the solution when we adopted those new projectiles which have been called by us "*granate dirompi*", in France "*obus brisants*", and in Germany "*Spreng-granaten*" (torpedo shell).

Charged with specially violent explosives these shell are not, as was at first supposed, capable of sending fragments backward, but produce nevertheless

a sheaf so wide that we can reach an enemy, however well defiladed he may be, always supposing that the point of bursting is situated directly over the trench which serves as cover. The opening of the sheaf is, as a matter of fact, 140°, that is to say, twice as great as with the ordinary shell. As regards the explosive itself, picric acid is well adapted for charging these projectiles, hence its growing favor in the artilleries of the various countries.

From what precedes it is clear that the most appropriate fuse for the torpedo shell is the time fuse, since it alone permits of bursting the projectile at the instant it is about to pass over the objective. Such precision in the bursting point is, however, difficult to obtain, at least as long as we remain tied down to the use of combustion fuses, fuses in which the mean probable dispersion* corresponds, as every one knows, to a depth of 50 m. in direct fire (with full charge).

To this cause must be attributed the divergences which result when these projectiles are used, and which consequently are inherent in their nature.

In Germany, where, in this case as in the case of ordinary shell, the principle in vogue is to reach the man and not the obstacle, the torpedo shell contains only sufficient charge to burst it, without reducing it to powder, and to communicate to the fragments merely the energy necessary to obtain the result sought. Thus, with this projectile, the effects sought are mainly those of time-fuse fire and not of percussion fire.

In France, on the other hand, they have little confidence in the efficacy of a projectile the action of which is entirely at the mercy of the irregularity of combustion of the fuse, especially since this irregularity is not compensated, as in shrapnel, by the depth of the zone struck. It is, indeed, well known that the radius of the space in which the explosion of a torpedo shell is dangerous is not over 10 meters (about 11 yards). It is necessary then, in order that the time-fuse fire shall be effective, that the projectile be provided with a mechanically perfect fuse, or that, according to the queer proposition of a still queerer inventor, it be furnished with special organs which will permit it to soar "like a falcon" and then swoop down on its prey at the proper moment and with proper precision.

Until one or the other of these desiderata is satisfied, the French, on the ground that the horizontal dispersion is less for percussion fire than for time-fuse fire, take the obstacle as objective for their torpedo shell. Without, therefore, giving the degree of defilement much consideration or attaching much importance to it, it is the epaulment which they attack, seeking above all to knock that down by powerful mining effects. Hence, instead of contenting themselves with 75 grams of picric acid as in the German shell,† they have adopted the enormous bursting charge of 1700 grams of melinite. Their projectile therefore acts like a veritable mine chamber, and, whether it explodes in the parapet or bursts on the ascending branch of a first ricochet, it cannot fail to have some effect on the man who is resting against the interior slope of the epaulment.

For my part, without detriment to what I am going to say further on, I consider that, in this kind of fire, the French are not far wrong. The important point is, of course, to attain the object sought; that is the first and foremost purpose of all firing, and of two possible ways,—one killing outright one

* Twice the mean probable deviation.

† According to Batsch's Leitfaden (edition of 1896) the charge of the German torpedo shell is 170 grams. (N. du Tr.).

adversary every five shots, the other sending one man to the hospital at every shot,—I do not hesitate to announce my preference for the second.

I should add, however, that, if I were asked to give my view on this subject as a whole, I should declare myself decidedly opposed to both systems. I would condemn the use of torpedo shell in itself, if this shell is to be fired by direct fire whether by time or percussion fuse, and with the particular object of destroying the protection which intrenchments afford to their defenders. I base my opinion on the fact that at 2000 meters (between 2100 and 2200 yards)—the best fighting distance foi the field artillerey—the probability of hitting a trench having a relief of 60 cm. (2 feet) with our gun of 9 c. (3.5 in.) is hardly 0.25; from which it follows that, even by the French method, that is to say with the less uncertain of the two, we will have to expend considerable ammunition for a very meagre result.

Under these circumstances, if the question of "finding" the man behind the parapet can be settled without regard to financial considerations, I should say: "Let us adopt a piece for curved fire". But if a gun of this kind cannot be adopted, and I were compelled to use the torpedo shell with direct fire, I would give the preference to the French method, always remembering that had the adoption of this shell with this kind of fire been left to my choice I should not have hesitated to reject it.

Independent of the question of accuracy it is necessary to obtain a clear view as to what the conditions of the combat are when it becomes an important matter to dislodge, or "ferret out" an adversary from behind an epaulment.

Whatever the kind of fire which the attack adopts with its pieces of direct fire, be it an ordinary continuous fire, or the fire by squalls (if we may so express it) advocated by General Langlois, there will always come a time when the artillerists are obliged to suspend their fire or to increase its range, in order to avoid firing into their infantry. The assaulting troops will then be left to their own resources at the very moment when the support of the artillery would be of enormous value.

It is in this connection that the question of curved fire presents itself with all its force. Here, indeed, is a matter of the first importance, much more important than can possibly be the effort to fire into the interior of works and to overcome the protection afforded by defilement. To accompany the attack to within a short distance of the enemy with an effective fire, that should be *the* rôle of the artillery. Now, whatever the method employed, this condition is not attainable with direct fire, and for that reason, in my opinion, the adoption of a field howitzer is a necessity, and takes precedence in any question of reform of the "gun."

The objections which logistics and technics can raise against this idea are, of course, worthy of attention. The attempts made to turn off the whole question by the adoption of a torpedo-shell, prove that the introduction of a howitzer in the field material is not so very simple a problem. But it appears to me that in this case the exigencies of tactics should take precedence before everything else, because the success of assaults depends upon its requirements.

Now, tactics has already recorded several facts which support its demands.

From the most reliable reports it appears that in the siege of Port-Arthur several works were taken by assault, at the first flush, so to speak, because

the Japanese had batteries of Krupp howitzers, which were able to accompany the bayonets of their infantry almost to the point where they crossed them with the defenders.

The opposers of this view advance as an objection the complication in material and ammunition which would result from the adoption of a howitzer. But their arguments are not unanswerable.

In the first place, it will only be necessary to dispense with one of the guns now in use so that nothing in that respect will be changed, and the misconceptions which up to the present time made possible the present great variety in the ammunition will still have play.

Then again, was not the Piedmontese artillery, which won so many laurels in the first wars for independence supplied with both howitzers and guns? The former were not even in separate batteries, but were united with the guns in the same battery, forming mixed batteries.

Moreover, going back to a more remote epoch, did not all the field batteries of Europe have howitzers from the moment the Russians, in the last ten years of the century preceding ours, began manufacturing pieces of this kind? Did not these pieces have all the distinctive characters of the howitzer properly so called? Did not this system remain in force up to the day when the use of rifles came in and threatened to overthrow the kingdom of Saint Barbara?

And why were these howitzers given up? Because rifling made it possible to throw shell with the new guns. And also because the first rifled guns were found to have a trajectory sensibly more curved than those of the smoothbore guns, the ratio of the weight of the charge to that of the projectile having been diminished when the projectile was made oblong. At that time we were content with a single piece, since it combined in a sufficient degree the respective advantages of the gun and the howitzer.

To-day this is no longer true. In consequence of its gradual improvement, by successive steps, the gun has caught up with and even passed the flatness of trajectory which it formerly had. The old compromise can no longer be effected. The adoption of a field piece permitting of curved fire has again become a necessity, and the gun proper will itself benefit by this adoption, because, from the day it has no longer any but a special part to play, we will have better opportunity to perfect it.

I do not know what we as a nation are going to do, but, as far as other countries are concerned, I do not think that I am wrong in believing that the experience of Port Arthur will not be long in making the scales incline definitely in favor of curved fire. And I say "incline" advisidly, because it is well known that, notwithstanding the adoption of "*Sprenggranaten*" in Germany and "*obus brisants*" in France, these powers have not yet given up at least the study of the question of the adoption of a field howitzer.

In France, for example, two complete batteries of howitzers of 12c. mounted on carriages of peculiar form, were the objects of serious experiments during the year 1894.

Knowing this, and bearing in mind the resources at the disposal of France and Germany, as well as the rapidity with which they are accustomed to decide questions which concern their defense, it will not be surprising if we see them before long adopting this new type of piece. In that case, as Russia, Sweden, Spain, Switzerland and England have already pronounced

in favor of it, the number of countries to which we can turn in order to find companions in the same situation with ourselves will be very small!

—*Revue d' Artillerie*, January, 1896.

[*Translated from the Italian by* C. BENOIT, Captain of Artillery; *from the French by* J. P. W.]

b Armor and Projectiles.

Test of Massachusetts' Turret.

The turret of the battleship *Massachusetts* was tested at the proving ground at Indian Head on May 9 to determine whether the structure would properly support the armor when it was struck a heavy blow from a projectile. The turret was placed on large steel cylinders representing the rollers upon which it rests when aboard ship. A 10-inch 500-pound shot, with a velocity of 1700 feet per second penetrated the armor 6 inches and broke up, leaving the framing practically uninjured. A 12-inch shot with the same velocity cracked the armor plate from top to bottom, but did only slight injury to the framing. The entire turret moved 7 inches in the direction of the line of fire. A 12-inch shot with a velocity of 2000 feet per second penetrated the armor plate, the backing and the structure, passing entirely through the turret and breaking up on the cast-iron plate on the opposite side. The results show that the turret furnishes good protection to the guns and mounts within it as long as the armor is not actually penetrated.

—*Engineering News*, May 14, 1896.

Failure of an Armor Plate.—United States.

A 15-inch armor plate, 17 × 9 feet, weighing 38 tons, for the battleship *Iowa*, was tested at the Bethlehem Iron Co.'s proving grounds, May 5, by a shot from a 10-inch gun. A Carpenter projectile, weighing 500 pounds, was used, with a charge of 154 pounds of powder. The shot struck near the center of the plate and was shattered, the point being imbedded and welded in the plate, and the plate was split across its width. The splitting is said to have been the result of a flaw which had previously caused the rejection of the plate.

—*Engineering News*, May 14, 1896.

Trial of a Carnegie double-forged nickel-steel Harveyed plate, recently tested at Ochta, near St. Petersburg.

The plate measured 8 ft. by 8 ft. by 10 in. The details of the trial are shown in the following table:

Round.	PROJECTILE.		Striking velocity.	Striking energy.	Calculated penetration through iron.	Estimated actual penetration.
	Diameter.	Weight.				
	inches.	lb.	f. s.	ft.-tons.	inches.	inches.
1	6	88	2589	4090	19.2	7.9
2	6	88	2597	4116	19.3	8.5
3	6	87.35	2891	5063	22.5	10.2
4	9	402.7	1879	9856	20.6	11.75

The projectiles were all of Poutiloff make. The three first struck at 1½ degrees to the normal to the plate face and the last at three degrees. It may be observed that the first three rounds produced no cracks, and were, in fact, wholly defeated. Their calculated perforations were greatly in excess of what would have been expected that any 10 inch plate could resist until recently. Dividing the calculated perforations, which are worked by Tresidder's formula, by the plate's thickness, the figures obtained are: 1.92, 1.93, 2.25, and 2.06, implying that the plate resisted blows capable of perforating from 1.9 to 2.1 times its thickness of wrought iron. It is difficult to give its exact figure of merit in perforation, seeing that it was not completely perforated; also the last round got deeper in than that preceding it, although its calculated perforation was less, showing that the defeat was due, as of course we know, to the fracture of the shot, and that the larger shot held more stoutly together, and so delivered more of its energy in the work of perforation than the smaller ones. One interesting feature is the extremely high velocities employed. This is the first armor plate attack which we have seen made with velocities exceeding 2500 foot-seconds. The third round, it will be seen, struck with a velocity of 2891 foot seconds. This being so, it is instructive to note that the projectiles did not deliver an overpowering amount of their energy before they broke. Judging from one previous plate trial, it might have been thought likely that the 6-inch shot striking with this very high velocity would have done more justice to its theoretical power of penetration than the 9-inch striking at a thousand foot-seconds lower velocity. This we find was not the case. The projectiles, however, did get deeper than is usual for shot that are completely defeated. Was this due to their high velocity or to their high quality? Such questions cannot be answered until we all purchase each other's projectiles, and so compare their respective powers, or test them by some standard shot. The plate, it is needless to remark, is a first-rate one judged by any standard, but resistance to perforation is certainly more striking than its resistance to fracture. It will be seen that the smashing blow obtained by dividing the striking energy of the third blow by the probable weight of the plate, which we calculate as 11.72 tons, amounts to 432 foot-tons per ton of plate. This the plate resisted. That of the last blow is 841 foot-tons per ton of plate nearly. Under this the plate broke, the shot being, however, as we have seen, fractured and kept from perforating. As an example, both of a double-forged plate and of armor attacked by shot with very high striking velocity, this experiment is most interesting, and Messrs. Carnegie are to be congratulated on the result.

—*Engineer*, London, February 28, 1896.

c Powder and Explosives.

Experiments with Smokeless Powder, From the Powder Works of Max. v. Förster, Office in Berlin.

I. Experiments conducted in the factory on the 10th of March 1896. Physical and chemical examination of the powder.

The powder is guncotton powder in the form of small thin leaflets. Moisture: 1.5% (the powder was exposed to the air for two weeks in a cool place and aborbed only this amount of moisture). Chemical stability: 0.1 gram detonated at +175° +176° +175° C. mean, 175°.3 C. Chemical test: heated to 80° C. the powder gave no reaction to potassium iodide and starch paper after an hour's exposure to the reagent.

BALLISTIC EXAMINATION OF THE POWDER.

Rifles from the Steyer works M. 88, 1890. Diameter between lands 7.90 mm., for velocity measurements gun No. 3446, for gas pressure measurements gun No. 6281, with diameter of pressure guage 9.06 mm., measurement of pressure 13 mm. from bottom of cartridge case, copper cylinder 10 mm. thick, 15 mm. high, without initial pressure.

Weight of projectile 14.7 grams, charge 2.4 grams, length of cartridge 82.5 mm.

No.	V 25. m.	Mean and departure therefrom.	No.	Pressure in atmospheres.	Mean and departure therefrom.	Remarks.	Meterological observations.
1	620		11	3125		The powder burned with little smoke and no slow combustion effects.	Barometer 765 Hygrometer 70%. Temperature at the firing ground + 2° C. Temperature of the powder + 10° C.
2	619		12	2881			
3	617		13	2929			
4	628	624	14	3086	2985.4		
5	622		15	2941	242		
6	630	11	16	2893			
7	627		17	3113			
8	621		18	3074			
9	626		19	2883			
10	624		20	2929			

II. Firing experiments conducted by the Mauser Manufactory with a "leaflet powder" (guncotton in thin sheets) from the factory of Max v. Förster.

Oberndorf on the N., October 15, 1894.

Rifle No. 209, metallic ammunition, system Mauser, caliber 7.65 mm., material of projectile nickeled steel mantle, diameter of projectile 7.9 mm., length 31 mm., weight 13.7 grams (normal), charge 2.72 grams, knife for measurements of gas pressure 9.0 mm., copper cylinder with 1000 atmospheres initial pressure.

No.	V 25. m.	Mean and departure therefrom.	No.	Pressure in atmospheres.	Mean and departure therefrom.	Meteorological observations.
1	634		11	3082		Barometer 719.
2	634		12	3018		
3	640		13	3018	3058.6	Hygrometer 82%.
4	638	635.3	14	3018	139	Temperature at firing ground + 5° C.
5	632		15	3157		
6	631	10				
7	638					
8	639					
9	637					
10	630					

Target records obtained by the Mauser Factory with the same powder.
Obendorf. October 27, 1894.
Range 1200 meters.
Gun No. 209, caliber 7.65 mm., absolute sight elevation 1200 m.

Meteorological Conditions.

No.	Direction of wind.	Velocity of wind per second.	Barometer.	Thermometer. C°.	Hygrometer. %	Marksman.
1 to 10	W	0.8—2m.	715	+14	44	Wedler.

Height of rectangle of shots,	2.50 m.	1.94 m.
Width of rectangle of shots,	2.48 m.	2.06 m.
Total dispersion,	4.98 m.	4.00 m.

—*Deutsche Heeres-Zeitung*, March 31.

d Torpedoes.

* * * * *

e. Range and Position Finding.

Snail Shaped Pointing Cam for Elevated Batteries.

An apparatus for regulating automatically the elevation of guns by merely aiming at the target without graduated sight or telemeter.

In elevated sea-coast batteries the angle i which the visual ray, directed upon an objective point, makes with the horizon, otherwise called the angle of depression, is a function of the distance of this objective (Fig. 1).

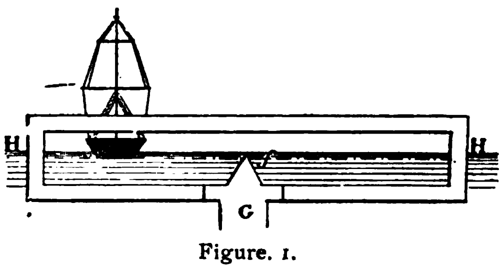

Figure. 1.

Aboard ship, sailors often use this angle to deduce the distance of some point. Extending this principle to gunnery, we see that for every inclination i of the line of sight, supposed to be directed at a target, there is, for cannon, a well determined inclination α with respect to the horizon which should be given to them, to reach the target in question. This fact served as a basis for Captain Deport of the artillery in constructing his pointing apparatus. But his instrument, ingenious as it is in conception, is extremely delicate, and can be placed only in hands trained to its use; it cannot, owing to this delicacy, support the shock of recoil, hence the necessity for removing it each time before firing, an operation which requires on the average eight seconds; during this interval sighting cannot be carried on, yet the target continues its motion. To rectify the error in aim which may result from this change of

position, the error must be estimated each time roughly; this rough estimate is always, it is easy to perceive, very difficult, even if we admit that the interval of eight seconds is maintained constant as they are now attempting to do practically by counting 1, 2, 3, 4 . . . 7, 8. Fire!!!

In short, the Deport telemeter, which calls for the greatest precautions in handling, is, besides, by its very position over the field, very much exposed in action, when the least fragment of stone is extremely liable to render it unreliable if not wholly useless. Moreover we see that the necessity of replacing this telemeter on the gun after each shot fired, of adjusting it, taking it off again and of counting eight, involves delays which are prejudicial not only to the rapidity, but to the accuracy of the fire.

Hence this method is defective in more ways than one.

The apparatus of which we now present the outlines, and of which the essential part consists of a solid eccentric wheel or cam in the form of a large snail, seems to us free from the objections just noticed. It too is based upon the principle of depression; but this is the only point of analogy between the two instruments, which are, as will be seen, of very different construction.

Principle.—The line of sight as upon all of our guns generally, is established by a front and a rear sight. But here, the rear sight *A*, instead of being mounted on the gun is on the top carriage.

While the rear sight is thus a fixture (or at least for greater clearness may be so considered for a moment), the front sight *G*, contrary to the usual practice is movable. Its motion depends upon that of an eccentric or cam *E* which forms part of the carriage. To this end the front sight forms the extremity of a stem or rod suitably guided by the directing socket *D* (Figs. 2 and 3).

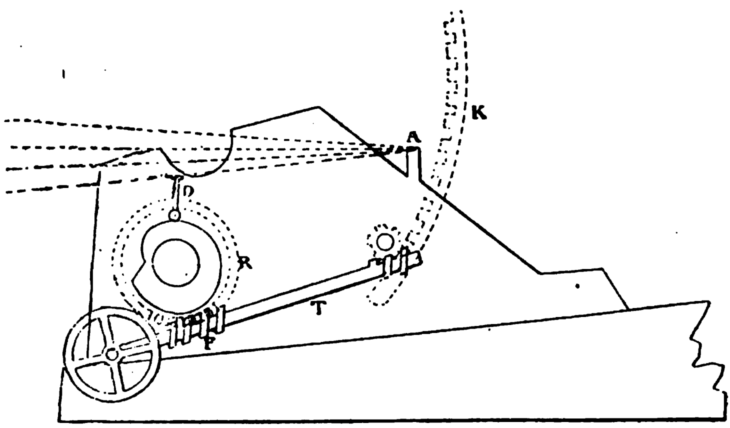

Figure 2.

The vertical movement of this front sight rod is regulated automatically along the line *G G′* by means of the cam, against which the rod is pressed by the bell shaped spring *r*.

The rod is provided at the lower end with a roller *g* for decreasing the friction against the surface of the cam *E* when the latter rotates, a rotation moreover which depends upon that of the gun, as will be seen presently.

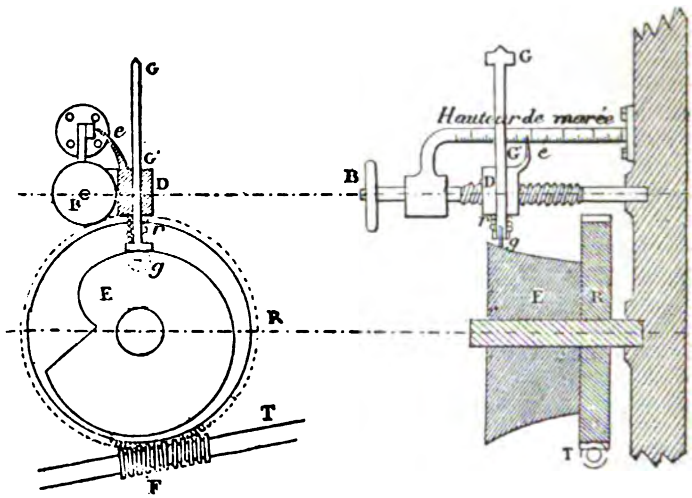

Figure 3.

Such being the case, the gunner has no way of sighting the object except by making the eccentric turn, and that while maneuvering the breech until the point to be struck shall be in the prolongation of the line of sight.

As soon as this obtains, the gunner commands "stop" to the men at the pointing crank, and the cannon has exactly the inclination i corresponding to the distance, so that nothing remains to be done but to fire the piece.

Thus, in short, the eccentric E forms a connecting link, subjecting the movements of the line of sight to those of the piece, and establishing between them an interdependence expressed by the function connecting the angle of elevation α with the depression i.

Details of the mechanism.—Let us take, for showing the process, a gun provided for elevating purposes, with a toothed arc K fixed to the breech, inasmuch as this is the pointing arrangement in most general use in our sea-coast batteries (Fig. 2).

This arc is as we know set in motion by means of a transmitting shaft T worked by the pointing winch and attached to the side of the top carriage (Figs. 2 and 3).

It is this shaft that, in our apparatus we utilize for moving the eccentric E (by means of an ordinary worm working in the toothed wheel R joined to the eccentric).

The shape of the eccentric, for a piece of the type given, will vary naturally with the altitude of the battery above the level of the sea and also with the state of the tide; whence the necessity, theoretically at least, for juxtaposing a series of cams each corresponding to a different tide; this juxtaposition is equivalent practically to the use of a single eccentric whose thickness for a given profile, equals the sum of those of all the others, which gives to this single eccentric the appearance of a truncated snail.

In order that the front sight rod may be guided by the section of the snail cam corresponding to the tide at the time, it must evidently be able to impart to this rod a lateral displacement: for this purpose its directing socket D may be given through a tangent screw B, a side motion of which the value is shown by the pointer e upon a tide scale (Fig. 3).

Such is the arrangement of the movable front sight; as to the rear sight which we have thus far regarded as fixed, it is really susceptible of being displaced laterally for corrections for wind and for speed of target, unless the method of division of labor in aiming which is described further on should be preferred, in which case the rear sight may be left stationary on the side of the top carriage according to our first hypothesis.

The sketch given is only a theoretical scheme of the apparatus. We apprehend that this very simple mechanism will be able to give great precision, upon the sole condition, and easy to realize too, that the vertical motion of the rod shall be directed truly by suitably placed guides.

Method of aiming.—Direction is given by the means now in use, the elevation likewise; but the method for accomplishing the latter is much simplified, since it is done without the assistance of graduated sight or telemeter; it is only necessary as soon as the loading is completed to direct the line of sight upon the target, without reference to the distance, and merely by so doing the gun is properly elevated.

Corrections for wind, speed and drift.—Corrections in aiming, that is those for wind and speed of target will be made, as we said before, by moving as usual the rear sight A, laterally. As for drift, since we here no longer use a graduated sight (the obliquity of which was intended to correct for drift) it will be necessary to use a toothed arc, as is done in the Silvani apparatus and similar ones, in order to compensate for it automatically.

Giving elevation and direction independent of each other.—The last experiments at Toulon have demonstrated the advantage of dividing these duties between two cannoneers, placed on opposite sides of the chassis; the one on the right, for example, devotes himself solely to giving the direction, while the other one, on the left, is required to give the piece the proper inclination. It goes without saying that nothing prevents applying this principle of division of duties to our process.

With this hypothesis the left side, where we suppose the snail shaped cam to be placed, will naturally be reserved exclusively for giving the elevation. To insure accuracy, the present rear sight will be replaced by a horizontal rectangular slot HH', crossed by a hair line f; to aim the piece it will evidently suffice to move the point of the front sight G, until both it and the water line of the hostile vessel coincides with the hair line in question, without paying any attention to the relative position of the points of coincidence on that line.

Giving elevation (left side of carriage).

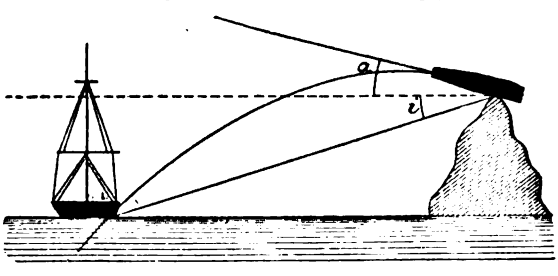

Figure 4.

Giving direction (right side of carriage).

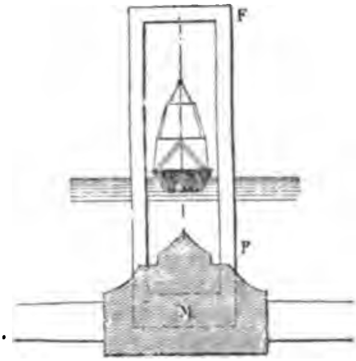

Figure 5.

As to giving directions, including the corrections for wind, speed of target and drift, this will be done on the opposite side, that is on the right side of the carriage. To regulate the direction an immovable alidade FF' and a movable cap M, both forming part of either the chassis or top carriage will be used (Fig. 5).

In short we see that the separation of these elements of aiming is entirely compatible with the use of the snail shaped cam; by the union of the two methods the distinct qualities which characterize each will be associated.

Precision of the apparatus.—All appliances based on the principle of depression, notably that of Captain Deport, show the same defect, which is, that beyond a certain distance the angle of depression i varies too little to enable the target distance to be computed therefrom, and hence the exact value of α. The snail shaped cam is no exception to this common law.

There is then for every battery a distance beyond which the snail cam, as is the case with all other depressing instruments, must be laid aside and recourse had either to the ordinary graduated sight or to horizontal methods (the distance being then given by some telemeter or other).—This distance which we call distance limit will be for the snail cam, practically the same as for the Deport telemeter, provided that care is taken to place the rear and the front sights sufficiently far apart (so as to render the variations of the tangent of depression represented by the variations of the radii of the cam more decided). This space (λ) between the front and rear sights should be as nearly as possible equal to 1½ or 2 meters, in order to have the instrument give good results; this condition is always easy to obtain.

It now remains to examine whether the play of the parts and the concussion of firing are not liable to modify the values of i and α respectively.

According to experiments which we made at Brest, mentioned in our note of November, 1892, it appears that the first of these influences, that of the play of the parts, will have no effect provided that in bringing the line of sight on the objective point, care is taken to obtain the coincidence in a way which shall always be the same, and which shall be agreed upon once for all. Let us say that the way adopted shall be by elevating from below. Under this hypothesis the line of sight must be directed upon the object, by an ascending motion of the front sight guide; if, afterwards, we have in order to sight, to lower the front sight, it will be necessary to continue this descending movement, so as to bring the line of sight slightly below the target, then at once

reverse the motion according to the prearranged method from below upwards, until coincidence with the point aimed at is obtained.

This first precaution, very easy to obtain from the least practical gunner, suffices to cancel every cause of error which can arise from the play of the parts. This will moreover be necessary only in the case of a very distant object.

At short and medium ranges it may be neglected, a slight error, having in this case, only an insignificant influence on the aim.

The only cause liable, perhaps, to change the indications of the snail shaped cam and of which we have not yet spoken, is the influence of the shocks incident to the discharge of the shots.

It is not possible before experiments have been made, to foresee whether these shocks will really affect injuriously the precision of the apparatus by modifying its connections; however, it is certain that its solidity places it in the best possible shape for resisting the shock of firing, inasmuch as the motion of the cam depends upon the aiming appliances of the piece, which have been specially constructed with a view to resisting this very shock. In any case this influence, if it exists, would be of the same kind as that of the gear, and does not come within the hypothesis under which we are working, of fire at restricted distances.

In short, we do not see that from any of the points of view which have just been examined, any objection can be raised against the new process with the reservation, we repeat, that its use be restricted to short and medium ranges. The snail shaped cam is not, however, alone in being subject to this obligatory restriction: it applies in a general way to all instruments based on depression; and whenever it becomes a question of reaching a very distant target, it follows that recourse must be had to one of the other ordinary methods, such as the graduated sight or the level.

Comparison with the Deport apparatus.—If the Deport telemeter and the snail shaped cam are placed side by side, it is seen that for both instruments the method of depression has served as a basis for the determination of the angle of fire, but that, in applying the method in the conception of the apparatus, different lines have been followed.

While for the Deport telemeter strict accuracy in obtaining the angle of aim has been sought, in the other we have above all sought to obtain a maximum rapidity of fire (*without however sacrificing accuracy, which will always remain sufficient if the target is not too remote*).

Hence the following characteristic differences:

1. The Deport telemeter has a telescope: the snail shaped cam sights along an open line.

2. The Deport telemeter, invented as an instrument of great precision incapable in consequence of sustaining the shock of firing, has been constructed upon the principle of absolute independence of the gun and carriage so it can be removed and thus avoid the shock of recoil.

On the contrary, the snail shaped cam is part with the gun, and its play, wholly bound up in that of the piece, is automatic.

In consequence of this double difference of principle, we have done away with the necessity of counting eight, objectionable owing to the change of position of the target; at the same time the delays incident to setting in place, adjusting and removal of every independent instrument before each shot are done away with.

For these two reasons, we can forsee that aiming with the snail shaped cam will be, in all probability, quite as accurate as that by the Deport telemeter, at least at short distances and certainly much quicker.

Besides, the new arrangement has the great superiority of not changing in any way the methods of aiming with which the cannoneers are familiar; these methods, although precise, are relatively rough, if as regards handling they are compared with those of the Deport telemeter.. The chances of error will be thus very much diminished since we shall avoid having to make delicate corrections under the fire of the enemy; add still that our apparatus accommodates itself to the method of division of the details of aiming, so much in favor since recent trials; and finally, with regard to corrections for tide, it operates in the simplest way and when it has been done once for all, it continues to be automatic thereafter, whatever may be the variation in the distance of the object to be struck.

In sum, the snail shaped cam, a strong mechanism, so well fitted to meet the usage of battle, does not require for its management the presence of a non-commissioned officer, like the Deport telemeter, it can be turned over to the nearest cannoneer, who will aim with it as he would with the ordinary graduated sight. and even more easily, inasmuch as he will have no data to receive from his captain in order to give elevation, the gun itself being its own telemeter.

Without insisting further, it is seen that the two instruments, although both based upon depression, act, if compared as to adjustment and to details of firing, in an entirely different way.

After having established this parallel, to which the sanction of experiment, is yet lacking, we hold it proper to remark that the criticisms made upon the Deport telemeter, are due solely to its extreme delicacy, which necessitates too great care in view of the object for which it is intended.

These objections, which we are not the first to bring up, do not in any way diminish the great value of Captain Deport's invention, who has the honor of having opened a new path in the important problem of sea-coast battery fire, by making the first pointing instrument based on angles of depression.

CONCLUSION.

The objection which may be raised against the snail shaped cam is the possible influence of vibrations upon the connections of the mechanism; but will not this defect, whose hypothetical existence remains to be proved experimentally, be largely compensated for, if found to exist, by the advantage of being able to follow the target to the last minute, instead of being obliged to cease sighting eight seconds before firing.

We have already pointed out that at short distances, this influence of vibrations upon the connections, will not have, on any case, any objectionable action on the accuracy of aim.

In short we arrive at the following conclusion:

The snail shaped cam, like every instrument based on depression, cannot be used for fire at distant objects.

On the contrary, at short and medium ranges it ought to give, theoretically at least, excellent results. If experiment confirms these opinions based on the preceeding considerations, such is the exceptional simplicity of this mechanism, that all of the sea-coast guns on high sites might be provided with them.

For distant targets, recourse would be had, either to the ordinary graduated

sight, or to the level; but, for short or medium ranges, the cam would be used exclusively, with the certainty of thus obtaining, with all necessary accuracy, a *rapidity of fire which cannot be claimed for any other method whatsoever.*

The new process appears then to be what would best suit the defense of comparatively narrow passes, because, in this case, rapidity of fire becomes a matter of imperative necessity.

APPENDIX.

Graphic Method.—The memorandum dated from Brest, December 12, 1892, contained no indication as to the construction of the eccentric. Since that time we have, thanks to the courtesy of the director of artillery, been able to procure, at that port, tables of fire, which have permitted us to fill that hiatus.

The given elements of the problem are the angles of elevation supplied by these tables, and the elevation of the battery above the level of the sea.

Let us take for example the Horse Shoe Battery at Brest, of which the altitude H is 27 meters, and let us seek the profile to give the cam, for the 32 c. guns constituting its armament, assuming for λ, the distance of the rear sight from the front sight, a length of $1\frac{1}{2}$ meters.

First prepare a table containing in column 1, a scale of ranges 200 meters apart; in column 2, the angles of depression i corresponding to these ranges; in column 3, the trigonometric tangents of these depressions; in column 4, the angles of fire given by the tables; in column 5, the differences between these angles and the corresponding depressions i of column 2, in other words the values previously termed α.

Col. 1. Ranges. P.	Col. 2. Depression. (i).	Col. 3. Tangents Trigonometric of depression.	Col. 4. Angle of Fire.	Col. 5. Difference between angles of cols. 2 and 4.	REMARKS.
	° ′	m/m	° ′	° ′	
200	—7 48 46	139 21	+ 0 09	— 7 40	Column 2. The depres-
400	—3 52 13	67 65	+ 0 24	— 3 28	sions are calculated by the
600	—2 34 45	45 046	+ 0 40	— 1 55	formula
800	—1 56 03	33 771	+ 0 56	— 1 00	
1000	—1 32 50	27 010	+ 1 13	— 0 20	$\sin i = \frac{H}{P} (H = 27 \text{ meters})$.
1200	—1 17 18	23 013	+ 1 31	— 0 14	
1400	—1 06 18	19 288	+ 1 49	+ 0 43	
1600	—0 58 01	16 878	+ 2 18	+ 1 10	
1800	—0 51 34	15 001	+ 2 27	+ 1 35	The numbers of Column 3
2000	— 46 24	13 498	+ 2 47	+ 2 01	express the tangents in the
2200	— 22 11	12 271	+ 3 18	+ 2 26	circle of radius unity.
2400	— 38 40	11 248	+ 3 29	+ 2 50	
2600	— 35 42	10 385	+ 3 51	+ 3 15	
2800	— 33 09	9 643	+ 4 13	+ 3 40	For greater simplicity, we
3000	— 30 56	8 998	+ 4 36	+ 4 05	have neglected the correc-
3200	— 29 00	8 436	+ 5 00	+ 4 31	tions for curvature of the
3400	— 27 18	7 941	+ 5 24	+ 3 57	earth and refraction which
3600	— 25 47	7 500	+ 5 48	+ 5 22	
3800	— 24 25	7 103	+ 6 13	+ 5 49	would have to be considered
4000	— 23 12	6 946	+ 6 39	+ 6 16	in an exact calculation.

In order that the eccentric or cam may properly express the relation sought between i column 2 and α column 5 it is necessary that:

1. The tangents of the angles (i) of depression shall be represented by the variations of the different radii of the eccentrics.

2. The values of α shall be represented by the angles separating these various radii.

To this end, we establish first the maximum and minimum ranges for the cam.

For the latter, we will not go lower than 250 meters, otherwise the curve of the eccentric would be too pronounced to insure the motion of the front sight rod satisfactorily.

(To fire on a target at a less distance, recourse would be had to the natural line of sight for elevation).

As to the maximum distance, variable with the altitude it would be best to decide it once for all experimentally. Let us suppose it to be 4000 meters for the battery in question.

To aim between these two distance limits, 250 and 4000 meters, the cam ought to make a complete turn upon itself, or 360°, while the angular displacement of the breech varying, according to our table, from $-7° 40'$ to $+6° 16'$, will reach at most about 15 degrees Besides, the rotations of the breech and of the eccentric, both depending on those of the elevation cranks, are proportional.

Let k be the constant relation according to which these two displacements vary. This constant relation is arbitrary; but it is for our interest, in order to diminish the curvature of the eccentric, to make it as large as possible; thus, in our example, we adopt $k \dfrac{360°}{15°} = 24$.

We have now all the necessary elements for the design of the cam.

It will suffice to carry out the following operations indicated by figure 6.

Describe a circle with any convenient radius.

Take the radius $= 0^m.40$, for example.

From the center lay off a number of radii making with one chosen as an origin angles respectively equal to the products of $k\alpha$, this is represented by $7°40' \times 24$, $3°28' \times 24$, etc.

These angles are laid off to the left of the origin if negative; to the right, if positive.

Upon each of the radii thus drawn, and starting at the circumference, lay off, towards the center, distances equal to the variations $\Delta\rho$ of the radius of the eccentric; these variations as we have said, are nothing more than the tangents of the depression (i), that is to say they are equal to the trigonometric tangents of column 3 of the table multiplied by the distance $\lambda = 1^m.50$ meters.

We thus obtain as many points as there are radii and their number is, besides, indefinite.

Join these points by a continuous line which will represent the profile of the cam.

§1.—In conclusion, notice that the angles of column 4 taken from the tables of fire, are absolutely true only for a horizontal line of sight. In retaining them thus we have therefore admitted implicitly the principle of the rigidity of the trajectory.

This hypothesis not being applicable to the case of elevated batteries firing at short range, it will only be necessary to make in the angles of column 4, and hence in those of column 5, a small correction, well known in artillery, to obtain the outline of the eccentric with the utmost exactness.

Profile of the cam for a 32 cm. gun. Horse Shoe Battery. Reduced Scale. The elements taken, of which a few differ from those in the table are:

$\lambda = 2\,m.\quad k = 20.\quad \rho = 0^m.40.\quad H = 27\,m.$

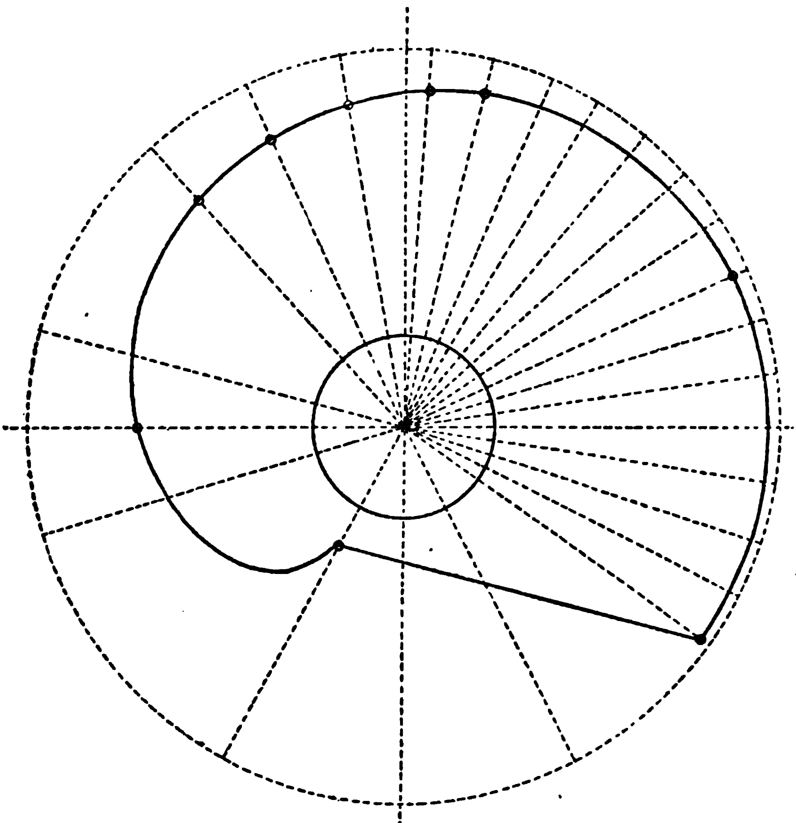

Figure 6.

In order to diminish as much as possible the curvature of the eccentrics and to prevent the front sight guide rod from binding, it is our interest, as we have moreover done, to give to k and to ρ their maximum value. To determine ρ, the radius of the eccentric, we are absolutely limited only by the consideration of bulk.

We can, besides, diminish the volume of the cam very much by dividing the play $\Delta\rho$ of the front sight G, between it and the rear sight, allotting one half to each. In this case the rear sight would also become movable and be supplied with an analogous cam.

§2.—The very principle of the snail shaped cam supposes the masonry platform of the gun to be perfectly horizontal.

Practically this is not at all the case, and the traverse circle upon which the carriage rolls may be several minutes out.

In this case, if the distance from the target is considerable, a little correction becomes necessary; to effect this, the rear sight A, instead of being

rigidly fixed to the top carriage has a slight vertical movement. This displacement is regulated by the readings of a little level set in the chassis. This level reading and change is done by another gunner without requiring the man at the sight to stop his sighting. When the object is within short or medium distances, the error in aim, arising from this defect in the platform may be neglected and there is no necessity for taking the trouble to make the correction for it.

Naiade, August 27, 1893,
H. DE KERILLIS,
Lieutenant.

[Translated by Captain G. G. Greenough, Fourth Artillery, U. S. Army.]

WAR SHIPS AND TORPEDO BOATS.

Merchant Steamers as Navy Vessels.

On the 21st of October the fast steamer *Normannia* of the Hamburg-American Line under the command of a navy captain was placed in service at Kiel for fifteen days. With this steamer the attempt was made for the first time in the German Navy to determine to what extent such reserve ships can replace cruisers and despatch boats. The special conditions of construction which the Navy Department imposed on the Hamburg-American and the North German Lloyd lines, in return for a subsidy granted them, and according to the terms of a special war contract, which guarantees indemnity against loss, are in the main as follows: The body of the ship to be made with double walls and protected by a system of compartments reaching up above the water level; for the purpose of communication doors to be retained, but to be such as can be closed water tight. Machinery and boilers are protected by coal bunkers; the coal in these is a reserve fuel, and can only be used in extreme necessity. In a ship of the size of the *Normannia* (8520 tons gross capacity) the ordinary coal bunkers hold 1750 tons. The ammunition magazines lie protected in the ship's hold, and are so arranged (as is the case in naval vessels) that they can be put under water. For the armament there are carriages for four 12.5 cm. (4.92 inch) guns, *L*/30, two of which stand in the bow and two in the stern, for fore and aft firing, also others for eight 15 cm. (5.9 inch) guns, *L*/25, in a broadside, for two 9 cm. (3.5 inch) guns, for two 56 mm. (2.2 inch) quick-fire guns, for six 37 mm. (1.5 inch) rapid-fire guns and for eight mitrailleuses. In the way of ammunition there are 150 rounds supplied for each gun of medium caliber, 200 for each gun of small caliber, and 1000 for each quick-fire gun. In addition, the steamer carries two small torpedo boats of 22 tons displacement each, with special arrangements for lowering and raising. For each torpedo boat eight torpedoes are provided. Such an auxiliary steamer would rate at least as high as the third class cruiser *Gefion*.

The question of manning these auxiliary cruisers would present no difficulties, since in our country with universal service the larger part of the men on every steamer have served in the navy. This is as true of the engineers as of the sailors, and it would be merely necessary in time of war to put on board, besides the staff, several petty officers and a few sailors of the navy.

—*Mittheilungen aus dem Gebiete des Seewesens*, No. XII, 1895.

BOOK NOTICES.

Johnson's Universal Cyclopedia. A new edition prepared by a corps of thiry-six editors, under the direction of Charles Kendall Adams, L.L.D. President of the University of Wisconsin. D. Appleton & Co. New York. 1893-1895. $6.00 per volume.

Encyclopædias, we are told by one who made great use of them, are books "where one may learn without cost of research what things are generally known. For it is far more useful to know these than to know those that are not generally known". (Lowell, *Books and Libraries*).

The work before us is now complete in eight volumes, containing each over nine hundred pages in which are treated from five to six thousand subjects, and in the selection of the subjects and the character of the articles it conforms in a remarkable degree to Lowell's idea of what a cyclopædia should contain.

The editor-in-chief as well as his corps of assistants are each and all men prominent in the departments which they have undertaken to direct. The managing editor, Robert Lilley, had previously had the invaluable experience of being one of the editors of the Century Dictionary. Among the associate editors we find such names as Dr. William T. Harris, United States Commissioner of education, Professor Theodore S. Woolsey of Yale University, Professor Ira Remsen of Johns Hopkins University, Simon Newcomb, Editor of the United States *Nautical Almanac*, Professor Mansfield Merriman of Lehigh University, Ainsworth R. Spofford, Librarian of Congress, Professor M. W. Harrington, ex-chief of the United States Weather Bureau, and others of equal promience, with Rear-Admiral Stephen B. Luce as naval editor and Professor James Mercur of West Point as military editor. Such names as these are a sufficient guarantee of the excellence of the entire work.

In every article of importance the first thing that strikes the reader is the *pronunciation* and the *etymology*, both of which are often of great importance, and when presented in the simple, clear and easily understood form in which they occur here it is a matter of great convenience and satisfaction to the ordinary student.

The mode of treatment of the subjects is such as makes the articles the most generally useful, purely technical treatises having been carefully avoided. But perhaps the highest praise is to be bestowed on another quality, particularly valuable in this age of rapid progress, viz: the fact that an especial effort has been made to bring the record of facts in all articles *up to date.* In this respect we know of no work of its kind that can compare with it. A marked departure from general custom in cyclopædias is the inclusion among the biographies of brief sketches of *noted living men and women.*

Finally, every important article is accompanied by copious *bibliographical information*, enumerating the best works in which to pursue the subject further. These are generally limited to English works, either original or translated, and, although this rule is departed from in several instances, the notices are often on this account unsatisfactory, because the literature of many subjects (especially in the domain of military matters), giving the latest and

best information, is in a foreign tongue, generally French or German, and in some subjects *no* information of recent date is available in English books.

To the military student, besides the valuable historical, biographical and geographical articles, and many minor articles on military subjects and terms, the most noticable articles are the following:

Intrenched Camps, by Lieutenant-General A. H. Brialmont, Belgian Army.

Franco-German War, by Captain August Niemann, editor for Genealogy and Diplomatics of the *Almanach de Gotha*.

Second Battle of Bull Run, by General Fitz John Porter.

Hell Gate, by General John Newton, United States Engineers.

Torpedoes and *Explosives*, by General Henry L. Abbot, United States Army.

Gunnery and *Gunpowder*, by Captain James M. Ingalls, United States Army, Instructor at Artillery School.

Fortification, *Siege* and *War*, by Colonel O. H. Ernst, United States Engineers, Superintendent of the Military Academy.

Armor, by Professor P. R. Alger, United States Navy.

Army, *Artillery*, *Ballistics*, *Bombardment*, and *Military Bridges*, by Professor James Mercur, United States Military Academy.

Ordnance, by General John C. Tidball, United States Army, formerly commanding the Artillery School.

Machine and Rapid-Fire Guns, by Captain Lawrence L. Bruff, head of the department of ordnance at West Point.

Magazine Guns, by Captain A. H. Russell, Ordnance Department, United States Army.

Small Arms, by Captain S. E. Blunt, Ordnance Department U. S. Army.

Ships of War, by Captain F. T. Bowles, Naval Constructor, U. S. Navy.

Torpedo Boats and Vessels, by Lieutenant G. F. W. Holman, United States Navy, Torpedo Station, Newport.

Steel, by C. Kirchhoff, editor of *The Iron Age*, New York.

Steam Engine, by Professor F. R. Hutton, Columbia College.

Transportation, by Professor A. T. Hadley, of Yale University.

Food, by Professor E. T. Reichert, University of Pennsylvania.

Russia, by Charles Emory Smith, L. L. D., Ex-United States Minister to Russia, Editor of *The Press*, Philadelphia.

France, by Lieutenant-Colonel F. Prudent, French Topographical Engineers.

Turkey, by Professor E. A. Grosvenor, Amherst College, formerly professor of history in Robert College, Constantinople, Turkey.

Great Britain and *German Empire*, by E. G. Ravenstein, member of the councils of Royal Geographical Society and Royal Statistical Society, London.

The articles on the American Indians and their language are full of interest, accurate and complete; indeed, this subject has never before received such careful investigation as it has here at the hands of Major J. W. Powell, Director of the United States Bureau of Ethnology, and his co-laborers in this field. The only other work at all to be compared with this one in that respect is Larned's History for Ready Reference and Topical Reading.

These are sufficient to illustrate not only the value of the work to the military student as a book of ready reference, but also its general character, since the quality of the material, as well as the standing of the authors, is quite as high in the other departments as in this.

We have found this cyclopædia more generally useful than any other, and the material found on consulting it nas been generally satisfactory. Indeed, if we may be permitted to state our opinion in other words, were we to recommend a few books as *essential* to a library of any pretentions we would recommend the Century Dictionary. Johnson's Universal Cyclopædia, Stieler's Atlas, a good geographical gazetteer, and Larned's History for Ready Reference, and in the order named.

J. P. W.

De la Puissance de Feux. Par le General E. Schneegans. L. Baudoin et cie. Paris.

The title of this interesting little volume is somewhat misleading. It is really a tactical discussion of combat and battle for the regiment, the corps and the army, concluding with a "hypothetical attack by a German army." The author writes with a directness which is refreshing. One does not have to wade through pages of "filling" to find grains of wheat.

The tactical principles set forth conform to the most recent French regulations for infantry. Whole companies must be placed in the firing line, supports are suppressed and the reserves are held in double open columns, echelonned in depth and breadth as long as possible. "The chain ought to conform to the following rules: seek positions from which the most harm can be done to the enemy; profit by executing well regulated fire from behind masses of cover; form the chain by a line of skirmishers *elbow to elbow*, when the position is favorable for fire and within mean distance of the enemy; place the front so as to reach the enemy by oblique enfilade or reverse fire; cover the assailants with cross fire; traverse rapidly flat and open ground, and make the men lie down to fire only when they have begun to lose breath; never halt without an order, and make every effort to maintain order and connection."

He believes these principles should be engraven on the memories of the skirmishers, and be practiced on the ground, so the men may grasp the spirit of the action. The chain will rarely succeed in capturing a well defended position at the first effort. Blow upon blow will be necessary. To renew an unsuccessful attack, new elements must be drawn from the reserves and be placed at the head. Whatever the situation may become, the combatants must march towards the indicated objective, and when the "confusion has become such that command is an idle word" they must rally around the first officer they see.

These ideas are excellent; their execution is possible only by troops of magnificent discipline and courage. He does not favor night attacks. "It will be more perudent to organize a methodical attack at daybreak." In the attack, fire at great distances ought to be of short duration, and preferably by volleys; at middle and short ranges, fire at will with the intensity carefully regulated is the only practical method. The defense can with advantage fire volleys at all the ranges. Up to the decisive effort the maximum fi e effect is produced by a single rank, elbow to elbow, unless there is cover of a particular kind. At close ranges with favorable cover, companies may be thrown into the chain in double rank. The art of maneuvering consists principally in disposing the troops so as to give their fire greater efficiency without exposing them to losses out of proportion to the object to be attained.

Prolonged fire contests without appreciable results should be avoided. It is better to go forward resolutely and thus hold a superiority in morale.

He regards both methods of advance with equal favor. The first, by alternate rushes, delays the march, destroys the connection and gives rise to accidents by fire, but offers the advantage of being able to continue the fire with part of the chain, which is worth considering in varied and irregular terrain. The second is simpler and permits more rapid progress over dangerous ground. Under a murderous fire it is possible that the first method must be imposed. It may be advantageous at times to pass from one system to the other.

His views are excellent, but very discouraging to a nation which expects to rely on hastily raised and untrained levies. He does not have unlimited confidence in the chain. In advancing to the attack in difficult circumstances he says "It will represent no more than *un pêle-mêlé flottant à l'aventure.*" I am inclined to the opinion that this will be its usual condition with any but well seasoned and highly disciplined troops, and that the effective blows must be struck by troops from the rear, kept well in hand, and quickly brought up at the critical moment.

Writing of artillery fire, he expresses the following views.

The conditions surrounding the defense are good when its artillery is not dominated and has good views of the terrain in front and on the flanks. The experiences of war and fire exercises, have abundantly demonstrated that a group of batteries cannot be taken by infantry in a front attack, unless it can approach under cover. The fact that artillery can turn its fire rapidly on a moving object at unknown distances is well established. The artillery of the defense will have the advantage of first choice of position, and probably protection behind fieldworks and gun pits. If the defense preserves its sang-froid, it may let the tempest of fire pass, reserving its own for the moment the columns move to the attack. In modern battles the artillery has occupied about one-third of the line of battle, and the infantry has passed the batteries without great difficulty.

In future battles the number of guns will be much greater, and the infantry will be compelled to make longer movements hurtful to rapidity of deployment. If the infantry is permitted to pass through, the fire of some batteries will be silenced. If the question of the débouché presents great obstacles, the hours of the night may be used to push the troops in rear ahead of the artillery. In considering the enormous masses of troops which will be mobilized in the next war he is convinced that several days will be necessary to bring them to the field of battle and deploy them. The first engagements will take place before the armies are in position. How is the cannonading to be continued during such a long time? Particular dispositions must be made to supply men and ammunition to the batteries.

Rapid fire is one shot per minute per piece; moderate fire 45 shots per hour. If the duel last six hours, it means 270 shots, a little more than the allowance per piece for an army corps; the rapid fire is only executed to obtain superiority of fire, after that is gained we must fire more slowly.

As soon as the batteries having good view of the points of attack have acquired superiority of fire, a part must continue to crush the adverse artillery, and the remainder must shell the point of attack, crests favorable to the defense, and the reserves. When the artillery sees that part of the chain has ceased to progress, arrested by the enemy's fire, it must aid it. Although the rule is that batteries must change objectives only after having obtained decisive results, they must protect an attack that is becoming feeble. A good

effect is produced on the morale of infantry by exploding shells in the enemy's ranks.

It is difficult to understand satisfactorily the "hypothetical attack by a German army" without good topographical maps of the Franco-German frontier.

In conclusion he says, "tactics has been given an influence on the success of operations, which it has not always deserved. A chief who cannot electrify his troops, and inspire in them the same confidence he feels, will often find his most ingenious combinations fail against an enemy who has firmly decided not to give ground".

J. S. Pettit,
Captain First Infantry, Military Instructor, Yale University.

Waterloo. A Narrative and a Criticism. By E. L. S. Horsburgh, B. A.. Queen's College, Oxon. Methuen & Co., 36 Essex Street, London, 1895. Pp. 312. Five shillings.

The general character and purpose of this new work on the ever interesting subject of the final overthrow of England's greatest antagonist is perhaps best given by quoting from the author's preface, dated June, 1895:

"The works of Charras, Clausewitz, Siborne, Chesney, Ropes, and many others, are well known to all students of military history, but owing to their length or their severe and technical style, they are but little read by the general public. The present volume, based upon a close study extending over many years of all the available authorities, claims, within a reasonable compass, to present the conclusions of experts upon controversial points, to suggest solutions to problems about which experts are in conflict, and to give a concise and faithful narrative of events".

As a whole this account of Waterloo is perhaps the fairest, the least prejudiced, that has been published in England, and in that respect compares favorably with the history of Ropes, which still retains its position as the standard account of the campaign, the classic on the subject of Waterloo. There is this great difference, however, between the two books,—while the American creates the feeling that in spite of all his misfortunes Napoleon was still the master mind on this occasion, the English leaves you with the impression that in spite of all his mistakes in strategy, Wellington's success must be regarded as proving him the greater soldier.

Up to and including the battle of Ligny it leaves nothing to be desired on the score of impartiality. In regard to Quatre Bras, for example, he remarks:

"Ney had sent no information upon the conclusion of the action of Quatre Bras of how things had gone with him that day. * * * Had Napoleon known that the allied army was still before Quatre Bras, isolated from Prussian support, exposed to an immediate attack, it is impossible to imagine that he would have hesitated to march at early morning for the purpose of overwhelming it. Had this been done, say at 6 or even 7 a. m., it does not appear that anything could have saved Wellington from destruction".

But beyond that point the account of the campaign is not always unprejudiced, as is evidenced, for instance, in the enthusiastic praise bestowed upon the charges on the English side at Waterloo, while those of the French, although the bravery of the troops is highly commended, are too often designated as rash and useless, and also in the evident dislike of Napoleon for his expression of delight when he found that Wellington determined to make a stand at Mont St. Jean. "Instead of that overweening confidence which is expressed in the exclamation, '*Enfin je les tiens, ces Anglais!*' should he not

rather have gathered from what he saw before him that the English had taken position in reliance upon some support not yet apparent?"

He sums up Grouchy's mission as a mistake on Napoleon's part, "a vague and ill-calculated errand". And yet we cannot but believe that a soldier competent to conduct such an independent command, like our own Sheridan, for example, would have been at Waterloo with Blücher or before him. Nor are we prepared to accept the soundness of the following as a principle in the art of war: "he was expecting the Prussians to come up upon his left, and could thus afford to leave it comparatively weak until that support should arrive".

But, aside from these points (some of which will probably always be matters of dispute), there is little to find fault with; the facts are stated in good faith in all cases, and the criticisms are made with sound judgment.

The interest of the story is well sustained—there is not a page in it that does not appeal to the student of military history—the descriptions are full of life and energy, the account is accurate and clear, and the criticisms show the result of long and careful study, indeed, it constitutes an exceedingly readable and enjoyable volume, well worthy of careful study, presenting as it does new points of interest worthy of attention.

The book is printed on excellent heavy paper, in large clear type, and contains eight good maps and diagrams. A list of these maps, giving the pages where they are to be found, would add something for the convenience of the reader.

J. P. W.

"Die Anwendung von beständigen und Feld Befestigungen" von Karl Kuk, Major of the Austrian Engineer Staff, Vienna, 1896.

This is a pamphlet of 95 pages, mostly condensed from von Leithner's more elaborate and detailed work, of which the second edition appeared in 1894.

It is a very complete general discussion of the whole subject of fortification, without any drawings. Its European origin is evident throughout from the minuteness of definition. The value of the pamphlet to military engineers will lie in the very complete assembling of the ground principles upon which their constructions must be based and of the conditions which those constructions must fulfill.

Definitions and conditions are exemplified by citation of the countries and localities to which they are applicable, thus giving a valuable detailed picture of the character of permanent fortifications throughout Europe.

The book is in no sense a text-book and contains but few dimensions. Such numbers as are given show however the general tendency of military engineering on the continent.

It is stated that guns of attack on an intrenched camp must be regarded as capable of 11000 yards range. Hence the line of defense must be 7500 yards from the area to be defended, because the effective range of field guns is assumed as 3500 yards. Assuming 2500 yards as the radius of the camp proper, we have 10000 yards as the radius of the line of defenses with a dangerous spare 3500 yards wide outside of that.

The necessary defensive force for such a line is put at one infantryman to four paces of circumference and one gun to two hundred paces of circumference. The total force required to defend such an intrenched camp is put at three infantrymen to four paces of circumference, and one gun to one hundred paces of circumference.

The extreme effective range of shrapnel from field guns is put at 3000 yds.

The heaviest mortar projectiles to be expected in the field are said to have a bursting charge of 50 lbs. of ecrasite; "torpedo" shells of 15 lbs.; and bomb proofs must be secure against this although no thicknesses are given.

The ammunition supply is put at

200 rounds per 24 hours for quick-fire and field guns.
80 rounds per 24 hours for long range duelling.
40 rounds per 24 hours for heavy (field) mortars.

It is stated that 90% of losses in battle are due to infantry fire and the following cover is recommended:

Against infantry 1.25 yds. earth. Against field guns 5 yds. earth.
Against infantry 1.25 yds. wood. Against field guns 2 yds. masonry.
Against infantry 0.36 yds. masonry.

It is stated that infantry reserves in battle will have to be kept prone unless covered well.

Captain T. A. BINGHAM, Engineers.

Aide-Mémoire de l'Officier de Marine, de Edouard Durassier, Chef de bureau au Ministère de la Marine, continué par Charles Valentino, ancien officer de marine, 9e Année, 1896. Paris: Henri Charles-Lavauzelle; 11 Place Saint-André-des-Arts.

This publication now in its ninth year is a compendium of naval information designed as a vade-mecum for naval officers. It contains 800 pages in small type, printed on thin paper, and forms a book not larger than our familiar Tidball's Manual. In this space the latest available information in regard to the navies of the world is condensed and arranged with the clearness and method characteristic of the French. The official positions of the authors have given them access to abundant material.

The bulk of the manual consists of tables in which the navy of each nation is taken up, its warships and torpedo-boats classified and tabulated, together with full data as to date of launching, dimensions of hull, character of machinery, amount of armor, strength of artillery, number of torpedo-boats and crew required. There is separately given in addition to these tables a succinct description of the type ships of each of the main naval powers. The types taken from the United States Navy are the *Indiana*, *Iowa*, *Battleships* 5 and 6, *Texas*, *Maine*, *New York*, *Brooklyn*, *Monterey*, *Katahdin*, *Miantonomah*, *Baltimore*, *Olympia*, *Columbia*, *Cincinnati*, *Detroit*, *Vesuvius*, *Yorktown* and *Machias*.

Next in importance to this account of the ships, which covers 500 pages, is the section devoted to naval artillery. Here we find tables of all the kinds of artillery used by the different navies, with full data in regard to each type of gun.

While the ships and naval artillery are thus the main features of the work, there are many other allied subjects discussed, which add to the usefulness of the work. For example, there is a section on modern torpedoes, a résumé of maritime international law, a description of the organization of the personnel of the different navies, a table for determining distances at sea (knowing the height of the object observed and the angle it subtends), tables for passing from the English to the metric system, and so forth.

This work is thus of special value to coast artillery as well as to naval officers.

G. B.

The Art of Supplying Armies in the Field.—Major H. G. Sharpe, Subsistence Department, United States Army.

The prize essay for 1895, by Major H. G. Sharpe, is a very interesting and readable paper. It is a pity the committee limits these essays to fifty pages of the magazine, for it is scarcely possible to discuss such an important and comprehensive subject in detail in twenty thousand words. In order to cover the matter in principles, the author is obliged to omit elaborations of important methods. We are all familiar with the usual rules laid down for supplying armies in the field and we understand the importance of communications, bases, transportation, etc. The science is not difficult, the art is very elusive; it evaded our staff very frequently during the first two years of the war, but after they fully comprehended the magnitude of the task before them they responded nobly. The first two years were marked by waste and extravagance. "After the battle of Antietam the size of the train with the army was * * * forty-nine wagons for every thousand men, * * * In the Appamattox campaign, twenty-two wagons and 239 draft animals per thousand men".

The resources of the north were inexhaustible, consequently the formation of great depots of supplies at railroad centers was an easy task; as they were not in danger of being attacked by the enemy, the military problem was not intricate. The establishing and maintainance of secondary bases offered some difficulties, but after the government took charge of the railroads, and after Gettysburg confined the Confederates to their own territory, this was simplified in turn. The real problem was to get supplies from the depots to the troops and the army mule and the old blue wagon became the sinews of war.

The methods of railroad management have improved greatly since 1865; the power and efficiency of the roads has probably been doubled; it is not certain that in the next war we shall have two or three years to devote to experimental work with military lines. Prudence and economy suggest that a careful and prolonged study of our railway systems, waterways, factories, and depots, with their carrying capacities and products, might well be made a compulsory part of the education of officers of the supply departments. The excellent work done during the last years of the war was done *in spite* of our bad staff organization, *not because* of it.

The magnificient record of General Rufus Ingalls has never been excelled in any army in all past time. His only reward was the scant gratitude of a republic, but also love, respect, and unbounded admiration of his comrades, from the private in ranks to his great commander, General Grant. His patriotic and unselfish devotion, asked only for the commendation of his fellow soldiers, and it was warm and unstinted.

Major Sharpe's essay is (from necessity probably) largely confined to the question of supply as viewed from a northern standpoint. We should like to see the Confederate side. Our difficulties were as nothing when compared to theirs during the last year of the war. With them the question of transportation was second to the question of finding something to transport. With every seaport closed and a country ravaged by four years of exhausting war, the last grand stand from the Rapidan to Appamattox must have been made under privations and suffering which our armies never knew.

The spirit, devotion and courage of those men, under starvation, are brilliant tributes to American manhood.

General Longstreet says, "Facts will not justify a commendation of the purveying department. Complaint had been made early in the war, and continued, of our inefficient subsistence department at Richmond. The diminishing resources of the country called for exceptionally earnest methodical, business faculties in these departments, especially that of subsistence, but unfortunately as our resources became more circumscribed, the officers instead of putting forth stronger efforts in their business seemed to lose the energy of their former service, and General Lee found himself called upon to feed as well as fight his army".

We hear that compressed foods and compressed forage are going to simplify the supply question. Our recent experiments with them have not been pleasing to the victims.

Major Sharpe very properly condemns the contract system. It will appear in a virulent form in our next war.

JAMES S. PETTIT,
Captain First Infantry, Yale University.

Strategisch-taktische Aufgaben nebst Lösungen. Colonel H. V. Gizycki (2nd Hanoverian Field Artillery, Regiment No. 26) Heft. 10, The narrow-gauge field railroad and the line of communication and supply.) Zuckschwerdt & Co. Leipzig, 1896. 2 marks (50 cents).

The series of strategic tactical problems of which this is a continuation was begun in 1884, but the first eleven numbers, reduced in number to nine, were completely revised in 1889, to conform to the new field regulations. The earliest numbers had been published anonymously, but the problems attracted so much attention and soon became so popular, that in 1886 the author's name appeared in connection with the revised numbers. The series is now being continued by Colonel Taubert, commanding the Railroad Regiment No. 3, and this number (10) is the first one to make application of the technical troops in these problems.

The general object of these problems is to promote the study of troop-leading as an *art*. Definite situations in various sections of country are fully discussed to aid in developing good military judgment, to assist the judgment in drawing reasonable conclusions rapidly, and to train officers in the issuing and wording of orders. They are based on the orders and regulations prescribing the duties of the Great General Staff, and are highly approved. not only by the principal military journals, but also by officers high in authority for their value to the army.

The number (10) here under consideration discusses the measures to be taken in laying a narrow-gauge road in rear of an army moving from Leipzig to Berlin, against a defeated army which has retreated to the eastward. In a pamphlet of fifty-three pages the author in clear and concise language presents the considerations which influence the officer in charge of this work and his final decisions. We can think of no better studies for the officers of an army, and know of no more valuable aids to general officers organizing maneuvers in summer camps of instruction. It is by such work alone that officers already familiar with the text-books of tactics and strategy, as well as the regulations for field service and the instructions for technical troops, learn to apply their knowledge in an actual case on a definite field, under known conditions. It is the last step in the training of officers for the handling of troops in the field and as such deserves careful study. The solutions given are never arbitrary, but present a number of possible solutions, and discuss

the various considerations involved in each, first from a *strategic* point of view, then from a *tactical* point of view and finally from a *technical* point of view, and having received the sanction of the chief of the general staff are invaluable as contributions to the art of war of to-day.

Our acquaintance with these problems since their first appearance twelve years ago warrants us in speaking with some authority, and we have nothing but praise for the entire collection.

J. P. W.

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* Denotes an original article. Italics denote *Book Notices.*

CORRIGENDA.

Page 319, Vol. V., lines 6 and 7 from bottom, for 37 and 67 and for 23 read 53.

Page 314, Vol. V., lines 17 and 18, for addition read subtraction, and for smaller read larger.